

二層膜および三層膜からの和周波(SFG)光

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ファイル「膜からの和周波発生」の延長として、膜層が2つのときの表式を求める。(3層以上になると、層の数と同数の次元を持つ行列の級数になるので複雑になる。ファイル「埋込発光層からの電場」の内容を参照すれば、ここで示す方式の延長として定式化することができる。)

1. 係数等

反射係数及び透過係数

光の電場を表面固定座標系の成分で表すときに、反射係数及び透過係数は下のようになることを使って、その座標成分を入射光電場の偏光成分で表すことにする。

$$\begin{aligned}
r_{1m,s} &= \frac{n_1 \cos \theta_1 - n_m \cos \theta_m}{n_1 \cos \theta_1 + n_m \cos \theta_m}, & t_{1m,s} &= \frac{2n_1 \cos \theta_1}{n_1 \cos \theta_1 + n_m \cos \theta_m} \\
r_{1m,p} &= \frac{n_1 \cos \theta_m - n_m \cos \theta_1}{n_1 \cos \theta_m + n_m \cos \theta_1}, & t_{1m,p} &= \frac{2n_1 \cos \theta_1}{n_1 \cos \theta_m + n_m \cos \theta_1} \\
r_{1m,x} &= -r_{m1,x} = r_{1m,p}, & r_{1m,y} &= -r_{m1,y} = r_{1m,s}, & r_{1m,z} &= -r_{m1,z} = -r_{1m,p} \\
r_{2m,x} &= -r_{m2,x} = r_{2m,p}, & r_{2m,y} &= -r_{m2,y} = r_{2m,s}, & r_{2m,z} &= -r_{m2,z} = -r_{2m,p} \\
t_{1m,x} &= (\cos \theta_m / \cos \theta_1) t_{1m,p}, & t_{1m,y} &= t_{1m,s}, & t_{1m,z} &= (\sin \theta_m / \sin \theta_1) t_{1m,p} \\
t_{m1,x} &= (\cos \theta_1 / \cos \theta_m) t_{m1,p}, & t_{m1,y} &= t_{m1,s}, & t_{m1,z} &= (\sin \theta_1 / \sin \theta_m) t_{m1,p} \\
t_{2m,x} &= (\cos \theta_m / \cos \theta_2) t_{2m,p}, & t_{2m,y} &= t_{2m,s}, & t_{2m,z} &= (\sin \theta_m / \sin \theta_2) t_{2m,p} \\
t_{m2,x} &= (\cos \theta_2 / \cos \theta_m) t_{m2,p}, & t_{m2,y} &= t_{m2,s}, & t_{m2,z} &= (\sin \theta_2 / \sin \theta_m) t_{m2,p} \\
t_{1m,\alpha} t_{m1,\alpha} &= 1 + r_{1m,\alpha} r_{m1,\alpha} = 1 - r_{1m,\alpha}^2, & t_{2m,\alpha} t_{m2,\alpha} &= 1 + r_{2m,\alpha} r_{m2,\alpha} = 1 - r_{2m,\alpha}^2, & (\alpha = x, y, z)
\end{aligned}$$

L 係数

L 係数とは、SFG 分極とそれから生成する SFG 光の電場振幅 E_{SF} を関係づける係数である。下式で示すように、電場に関しては座標成分ごとに、分極については偏光成分ごとに定義される。

$$E_{SF,\alpha} = \sum_{\beta} L_{\alpha\beta} P_{\beta}^{SF}$$

一般化された Snell の屈折式により、生成する SFG 光は上向き (-) 光と下向き (+) 光の両方になる。また、分極が存在する部位によって L 係数の表式が違ってくる。もともと導かれた式は、無限に薄い薄膜 m が分極し、そこから媒質 1 媒質 2 に出てくる光を考えたものであって、s 偏光と p 偏光の電場振幅を分極の x、y、z 成分と関係づけるものであるが、ここでは、拡張して考える。また、共通因子である $4\pi\omega_{SF}/c$ (屈折率の代わりに波数ベクトルを使うときには $4\pi\omega_{SF}^2/c^2$) を省略する。なお、上向き (-) 光および下向き (+) 光とは、それぞれ反射光と同じ方向 (-z 方向) に進む光と入射光や透過光と同じ方向 (+z 方向) に進む光を指す。

L 係数の表記法; $L_{ij\beta(p),\alpha}$: 分極シート m' が I 層と j 層に挟まれているときに、分極の α 成分 ($\alpha = x, y, z$) が作る光の s 偏光成分又は p 偏光成分の間の係数。上向き (-) 光、下向き (+) 光の区別を上付き -, + で示す。

媒質 1 と積層膜 m の間の分極シート m' からの SFG 光生成に対する L 係数は、下式で与えられる。

$$\begin{aligned}
L^-_{1/m,p,x} &= \cos\theta_{m,SF}/(n_{1,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{1,SF}) \\
L^-_{1/m,s,y} &= 1/(n_{1,SF}\cos\theta_{1,SF} + n_{m,SF}\cos\theta_{m,SF}) \\
L^-_{1/m,p,z} &= (n_m/n_{m'})\sin\theta_{m',SF}/(n_{1,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{1,SF}) = (n_m/n_{m'})^2\sin\theta_{m,SF}/(n_{1,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{1,SF}) \\
L^+_{1/m,p,x} &= \cos\theta_{1,SF}/(n_{1,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{1,SF}) \\
L^+_{1/m,s,y} &= 1/(n_{1,SF}\cos\theta_{1,SF} + n_{m,SF}\cos\theta_{m,SF}) \\
L^+_{1/m,p,z} &= -(n_1/n_{m'})\sin\theta_{m',SF}/(n_{1,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{1,SF}) = -(n_1/n_{m'})^2\sin\theta_{1,SF}/(n_{1,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{1,SF})
\end{aligned}$$

媒質 2 と積層膜 m の間の分極シート m'' からの SFG 光生成に対する L 係数は、下式で与えられる。

$$\begin{aligned}
L^-_{2/m,p,x} &= \cos\theta_{2,SF}/(n_{2,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{2,SF}) \\
L^-_{2/m,s,y} &= 1/(n_{2,SF}\cos\theta_{2,SF} + n_{m,SF}\cos\theta_{m,SF}) \\
L^-_{2/m,p,z} &= (n_2/n_{m''})\sin\theta_{m'',SF}/(n_{2,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{2,SF}) = (n_2/n_{m''})^2\sin\theta_{2,SF}/(n_{2,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{2,SF}) \\
L^+_{2/m,p,x} &= \cos\theta_{m,SF}/(n_{2,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{2,SF}) \\
L^+_{2/m,s,y} &= 1/(n_{2,SF}\cos\theta_{2,SF} + n_{m,SF}\cos\theta_{m,SF}) \\
L^+_{2/m,p,z} &= -(n_{m''}/n_{m''})\sin\theta_{m'',SF}/(n_{2,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{2,SF}) = -(n_{m''}/n_{m''})^2\sin\theta_{m,SF}/(n_{2,SF}\cos\theta_{m,SF} + n_{m,SF}\cos\theta_{2,SF})
\end{aligned}$$

積層膜内部の分極シートからの SFG 光生成に対する L 係数は、下式で与えられる。

$$\begin{aligned}
L^-_{m/m,p,x} &= L^+_{m/m,p,x} = \cos\theta_{m,SF}/(2n_{m,SF}\cos\theta_{m,SF}) \\
L^-_{m/m,s,y} &= L^+_{m/m,s,y} = 1/(2n_{m,SF}\cos\theta_{m,SF}) \\
L^-_{m/m,p,z} &= -L^+_{m/m,p,z} = \sin\theta_{m,SF}/(2n_{m,SF}\cos\theta_{m,SF})
\end{aligned}$$

上に示した電場と分極の関係式は、SFG 分極と SFG 光に限定されるものではない。振動分極と、それから生成する電磁波に対して、一般的に成り立つのである。

2. 二層系 (1/m'/m/2) からの SFG

2.1. 電場振幅の積

可視光の電場と赤外光の電場の積を下に示す。但し、位相部分については、SFG 光の経路が最外面で反射するとしたときのものを示すので、m'/m 界面及び m/m'' 界面での反射についても取り入れる必要があるときには、別途に考慮しなければならない。式の導出については、ファイル「二層膜からの和周波 (SFG)」の 4 節または「積層膜からの和周波発生 (SFG)」の 4 節を参照されたい。

1/m' 界面の 1 側：

(a): E^+ (by reflection and transmission) sources and E^- (for $n = 0$) source

$$\begin{aligned}
E_{vis\alpha}(0^-)E_{ir\beta}(0^-) &= E^0_{vis\alpha}E^0_{ir\beta} \\
&\times \frac{(1+r_{1m',vis\alpha})(1+r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}) + (r_{m'm,vis\alpha} + e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}}
\end{aligned}$$

$$\begin{aligned} & \times \frac{(1+r_{1m'jr\beta})(1+r_{m'mjr\beta}e^{2\beta_{m',ir}h_{m'}}) + (r_{m'mjr\beta} + e^{2i\beta_{m',ir}h_{m'}})r_{m2jr\beta}e^{2i\beta_{m,ir}h_m}}{1+r_{1m'jr\beta}r_{m'mjr\beta}e^{2i\beta_{m',ir}h_{m'}} + (r_{m'mjr\beta} + r_{1m'jr\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2jr\beta}e^{2i\beta_{m,ir}h_m}} \\ & \times \exp[2ni(h_m \tan\theta_{mSF} + h_{m'} \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (2.1)$$

1/m' 界面の m' 側：

(a): E^+ and E^- (by reflection) sources

$$\begin{aligned} E_{vis\alpha}(0^+)E_{ir\beta}(0^+) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\ & \times \frac{t_{1m'vis\alpha}[(1+r_{m'mvis\alpha}e^{2\beta_{m',vis}h_{m'}}) + (r_{m'mvis\alpha} + e^{2i\beta_{m',vis}h_{m'}})r_{m2vis\alpha}e^{2\beta_{m,vis}h_m}]}{1+r_{1m'vis\alpha}r_{m'mvis\alpha}e^{2i\beta_{m',vis}h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2vis\alpha}e^{2\beta_{m,vis}h_m}} \\ & \times \frac{t_{1m'jr\beta}[(1+r_{m'mjr\beta}e^{2i\beta_{m',ir}h_{m'}}) + (r_{m'mjr\beta} + e^{2\beta_{m',ir}h_{m'}})r_{m2jr\beta}e^{2\beta_{m,ir}h_m}]}{1+r_{1m'jr\beta}r_{m'mjr\beta}e^{2i\beta_{m',ir}h_{m'}} + (r_{m'mjr\beta} + r_{1m'jr\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2jr\beta}e^{2\beta_{m,ir}h_m}} \\ & \times \exp[2ni(h_m \tan\theta_{mSF} + h_{m'} \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (2.2)$$

m/2 界面の 2 側：

(a): E^+ source

$$\begin{aligned} E_{vis\alpha}(h_{m'} + h_m^+)E_{ir\beta}(h_{m'} + h_m^+) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\ & \times \frac{t_{1m'vis\alpha}t_{m'mvis\alpha}t_{m2vis\alpha}e^{i(\beta_{m,vis}h_m + \beta_{m',vis}h_{m'})}}{1+r_{1m'vis\alpha}r_{m'mvis\alpha}e^{2i\beta_{m',vis}h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2vis\alpha}e^{2\beta_{m,vis}h_m}} \\ & \times \frac{t_{1m'jr\beta}t_{m'mjr\beta}t_{m2jr\beta}e^{i(\beta_{m,ir}h_m + \beta_{m',ir}h_{m'})}}{1+r_{1m'jr\beta}r_{m'mjr\beta}e^{2i\beta_{m',ir}h_{m'}} + (r_{m'mjr\beta} + r_{1m'jr\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2jr\beta}e^{2\beta_{m,ir}h_m}} \\ & \times \exp[2ni(h_m \tan\theta_{mSF} + h_{m'} \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (2.3)$$

(b): E^- sources (for $n > 0$, by reflection)

$$\begin{aligned} E_{vis\alpha}(h_{m'} + h_m^+)E_{ir\beta}(h_{m'} + h_m^+) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\ & \times \frac{t_{1m'vis\alpha}t_{m'mvis\alpha}t_{m2vis\alpha}e^{i(\beta_{m,vis}h_m + \beta_{m',vis}h_{m'})}}{1+r_{1m'vis\alpha}r_{m'mvis\alpha}e^{2i\beta_{m',vis}h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2vis\alpha}e^{2\beta_{m,vis}h_m}} \\ & \times \frac{t_{1m'jr\beta}t_{m'mjr\beta}t_{m2jr\beta}e^{i(\beta_{m,ir}h_m + \beta_{m',ir}h_{m'})}}{1+r_{1m'jr\beta}r_{m'mjr\beta}e^{2i\beta_{m',ir}h_{m'}} + (r_{m'mjr\beta} + r_{1m'jr\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2jr\beta}e^{2\beta_{m,ir}h_m}} \\ & \times \exp[i(2n+1)(h_m \tan\theta_{mSF} + h_{m'} \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (2.4)$$

m/2 界面の m 側：

(a): E^+ (by reflection) and E^- sources

$$\begin{aligned} E_{vis\alpha}(h_{m'} + h_m^-)E_{ir\beta}(h_{m'} + h_m^-) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\ & \times \frac{t_{1m'vis\alpha}t_{m'mvis\alpha}(1+r_{m2vis\alpha})e^{i(\beta_{m,vis}h_m + \beta_{m',vis}h_{m'})}}{1+r_{1m'vis\alpha}r_{m'mvis\alpha}e^{2i\beta_{m',vis}h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2vis\alpha}e^{2\beta_{m,vis}h_m}} \end{aligned}$$

$$\begin{aligned}
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} (1 + r_{m2jr\beta}) e^{i\beta_{m'jr} h_m + \beta_{m'jr} h_m}}{1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_m} + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_m}) r_{m2jr\beta} e^{2i\beta_{m'jr} h_m}} \\
& \times \exp[i(2n+1)(h_m \tan\theta_{mSF} + h_m' \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{mvis} \sin\theta_{mvis})] \quad (2.5)
\end{aligned}$$

m'/m 界面の m' 側 :

(a): E^+ and E^- (by reflection) sources

$$\begin{aligned}
E_{vis\alpha}(h_{m'}^-) E_{ir\beta}(h_{m'}^-) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} e^{i\beta_{m'vis} h_m'} (1 + r_{m'mvis\alpha}) (1 + r_{m2vis\alpha} e^{2i\beta_{mvis} h_m})}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_m'} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'vis} h_m'}) r_{m2vis\alpha} e^{2i\beta_{mvis} h_m}} \\
& \times \frac{t_{1m'jr\beta} e^{i\beta_{m'jr} h_m'} (1 + r_{m'mjr\beta}) (1 + r_{m2jr\beta} e^{2i\beta_{mjr} h_m})}{1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_m'} + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_m'}) r_{m2jr\beta} e^{2i\beta_{mjr} h_m}} \\
& \times \exp[ih_{m'} \tan\theta_{m'SF} (-k_{mjr} \sin\theta_{mjr} - k_{mvis} \sin\theta_{mvis})] \\
& \times \exp[i(2n+1)(h_m \tan\theta_{mSF} + h_m' \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{mvis} \sin\theta_{mvis})] \quad (2.6)
\end{aligned}$$

(b): E^+ (by reflection) and E^- sources

$$\begin{aligned}
E_{vis\alpha}(h_{m'}^-) E_{ir\beta}(h_{m'}^-) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} e^{i\beta_{m'vis} h_m'} (1 + r_{m'mvis\alpha}) (1 + r_{m2vis\alpha} e^{2i\beta_{mvis} h_m})}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_m'} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'vis} h_m'}) r_{m2vis\alpha} e^{2i\beta_{mvis} h_m}} \\
& \times \frac{t_{1m'jr\beta} e^{i\beta_{m'jr} h_m'} (1 + r_{m'mjr\beta}) (1 + r_{m2jr\beta} e^{2i\beta_{mjr} h_m})}{1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_m'} + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_m'}) r_{m2jr\beta} e^{2i\beta_{mjr} h_m}} \\
& \times \exp[ih_{m'} \tan\theta_{m'SF} (-k_{mjr} \sin\theta_{mjr} - k_{mvis} \sin\theta_{mvis})] \\
& \times \exp[2ni(h_m \tan\theta_{mSF} + h_m' \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{mvis} \sin\theta_{mvis})] \quad (2.7)
\end{aligned}$$

m'/m 界面の m 側 :

(a): E^+ and E^- (by reflection) sources

$$\begin{aligned}
E_{vis\alpha}(h_{m'}^+) E_{ir\beta}(h_{m'}^+) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i\beta_{m'vis} h_m'} (1 + r_{m2vis\alpha} e^{2i\beta_{mvis} h_m})}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_m'} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'vis} h_m'}) r_{m2vis\alpha} e^{2i\beta_{mvis} h_m}} \\
& \times \frac{t_{1m'jr\beta} e^{i\beta_{m'jr} h_m'} (1 + r_{m'mjr\beta}) (1 + r_{m2jr\beta} e^{2i\beta_{mjr} h_m})}{1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_m'} + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_m'}) r_{m2jr\beta} e^{2i\beta_{mjr} h_m}} \\
& \times \exp[ih_{m'} \tan\theta_{m'SF} (-k_{mjr} \sin\theta_{mjr} - k_{mvis} \sin\theta_{mvis})] \\
& \times \exp[2ni(h_m \tan\theta_{mSF} + h_m' \tan\theta_{m'SF})(-k_{mjr} \sin\theta_{mjr} - k_{mvis} \sin\theta_{mvis})] \quad (2.8)
\end{aligned}$$

(b): E^+ (by reflection) and E^- sources

$$\begin{aligned}
E_{vis\alpha}(h_m^+)E_{ir\beta}(h_m^+) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{2\beta_{m',vis} h_m'} (1 + r_{m2vis\alpha} e^{2\beta_{m,vis} h_m})}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_m'} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis} h_m'}) r_{m2vis\alpha} e^{2\beta_{m,vis} h_m}} \\
&\times \frac{t_{1m'ir\beta} t_{m'mir\beta} e^{2\beta_{m',ir} h_m'} (1 + r_{m2ir\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m',ir} h_m'} + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m',ir} h_m'}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}} \\
&\times \exp[ih_m' \tan\theta_{m'SF} (-k_{m'ir} \sin\theta_{m'ir} - k_{m'vis} \sin\theta_{m'vis})] \\
&\times \exp[2ni(h_m \tan\theta_{m'SF} + h_m' \tan\theta_{m'SF}) (-k_{m'ir} \sin\theta_{m'ir} - k_{m'vis} \sin\theta_{m'vis})] \tag{2.9}
\end{aligned}$$

m' 層の深さ z_1 点

[$A_n^{(m')}$]: E^+ sources

$$\begin{aligned}
E_{vis\alpha}(z_1) &= E_{vis\alpha}^0 \frac{t_{1m'vis\alpha}}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_m'} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m',vis} h_m'}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
&\times \{(1 + r_{m'mvis\alpha} r_{m2vis\alpha} e^{2\beta_{m,vis} h_m}) \exp[iz_1 k_{m'vis} \cos\theta_{m'vis} (1 + \tan\theta_{m'SF} \tan\theta_{m'vis})] \\
&+ (r_{m'mvis\alpha} + r_{m2vis\alpha} e^{2\beta_{m,vis} h_m}) e^{2i\beta_{m',vis} h_m'} \exp[iz_1 k_{m'vis} \cos\theta_{m'vis} (-1 + \tan\theta_{m'SF} \tan\theta_{m'vis})]\} \\
&\times \exp[-i(2n+2)(h_m \tan\theta_{m'SF} + h_m' \tan\theta_{m'SF}) k_{m'vis} \sin\theta_{m'vis}] \tag{2.10a}
\end{aligned}$$

$$\begin{aligned}
E_{ir\beta}(z_1) &= E_{ir\beta}^0 \frac{t_{1m'ir\beta}}{1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m',ir} h_m'} + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m',ir} h_m'}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}} \\
&\times \{(1 + r_{m'mir\beta} r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}) \exp[iz_1 k_{m'ir} \cos\theta_{m'ir} (1 + \tan\theta_{m'SF} \tan\theta_{m'ir})] \\
&+ (r_{m'mir\beta} + r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',ir} h_m'} \exp[iz_1 k_{m'ir} \cos\theta_{m'ir} (-1 + \tan\theta_{m'SF} \tan\theta_{m'ir})]\} \\
&\times \exp[-i(2n+2)(h_m \tan\theta_{m'SF} + h_m' \tan\theta_{m'SF}) k_{m'vis} \sin\theta_{m'vis}] \tag{2.10b}
\end{aligned}$$

$$\begin{aligned}
E_{vis\alpha}(z_1)E_{ir\beta}(z_1) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{t_{1m'vis\alpha}}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_m'} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis} h_m'}) r_{m2vis\alpha} e^{2\beta_{m,vis} h_m}} \\
&\times \frac{t_{1m'ir\beta}}{1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m',ir} h_m'} + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m',ir} h_m'}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}} \\
&\times \{(1 + r_{m'mvis\alpha} r_{m2vis\alpha} e^{2\beta_{m,vis} h_m})(1 + r_{m'mir\beta} r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}) \\
&\times \exp[iz_1 (k_{m'vis} \cos\theta_{m'vis} (1 + \tan\theta_{m'SF} \tan\theta_{m'vis}) + k_{m'ir} \cos\theta_{m'ir} (1 + \tan\theta_{m'SF} \tan\theta_{m'ir}))] \\
&+ (1 + r_{m'mvis\alpha} r_{m2vis\alpha} e^{2\beta_{m,vis} h_m})(r_{m'mir\beta} + r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',ir} h_m'} \\
&\times \exp[iz_1 (k_{m'vis} \cos\theta_{m'vis} (1 + \tan\theta_{m'SF} \tan\theta_{m'vis}) + k_{m'ir} \cos\theta_{m'ir} (-1 + \tan\theta_{m'SF} \tan\theta_{m'ir}))] \\
&+ (r_{m'mvis\alpha} + r_{m2vis\alpha} e^{2\beta_{m,vis} h_m})(1 + r_{m'mir\beta} r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',vis} h_m'} \\
&\times \exp[iz_1 (k_{m'vis} \cos\theta_{m'vis} (-1 + \tan\theta_{m'SF} \tan\theta_{m'vis}) + k_{m'ir} \cos\theta_{m'ir} (1 + \tan\theta_{m'SF} \tan\theta_{m'ir}))] \\
&+ (r_{m'mvis\alpha} + r_{m2vis\alpha} e^{2\beta_{m,vis} h_m})(r_{m'mir\beta} + r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir}) h_m'} \\
&\times \exp[iz_1 (k_{m'vis} \cos\theta_{m'vis} (-1 + \tan\theta_{m'SF} \tan\theta_{m'vis}) + k_{m'ir} \cos\theta_{m'ir} (-1 + \tan\theta_{m'SF} \tan\theta_{m'ir}))]\}
\end{aligned}$$

$$\times \exp[-i(2n+2)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})(k_{m,vis} \sin\theta_{m,vis} + k_{m,jr} \sin\theta_{m,jr})] \quad (2.11)$$

$[\mathbf{B}_n^{(m)}]$: E^- sources

$$\begin{aligned} E_{vis\alpha}(z_1) &= E_{vis\alpha}^0 \frac{t_{1m',vis\alpha}}{1 + r_{1m',vis\alpha} r_{m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m',vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\ &\times \{(1 + r_{m',vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) \exp[iz_1 k_{m',vis} \cos\theta_{m',vis} (1 - \tan\theta_{m',SF} \tan\theta_{m',vis})] \\ &+ (r_{m',vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) e^{2i\beta_{m',vis} h_{m'}} \exp[iz_1 k_{m',vis} \cos\theta_{m',vis} (-1 - \tan\theta_{m',SF} \tan\theta_{m',vis})]\} \\ &\times \exp[-i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF}) k_{m,vis} \sin\theta_{m,vis}] \end{aligned} \quad (2.12a)$$

$$\begin{aligned} E_{ir\beta}(z_1) &= E_{ir\beta}^0 \frac{t_{1m',jr\beta}}{1 + r_{1m',jr\beta} r_{m',jr\beta} e^{2i\beta_{m',jr} h_{m'}} + (r_{m',jr\beta} + r_{1m',jr\beta} e^{2i\beta_{m',jr} h_{m'}}) r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}} \\ &\times \{(1 + r_{m',jr\beta} r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) \exp[iz_1 k_{m',jr} \cos\theta_{m',jr} (1 - \tan\theta_{m',SF} \tan\theta_{m',jr})] \\ &+ (r_{m',jr\beta} + r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',jr} h_{m'}} \exp[iz_1 k_{m',jr} \cos\theta_{m',jr} (-1 - \tan\theta_{m',SF} \tan\theta_{m',jr})]\} \\ &\times \exp[-i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF}) k_{m,vis} \sin\theta_{m,vis}] \end{aligned} \quad (2.12b)$$

$$\begin{aligned} E_{vis\alpha}(z_1) E_{ir\beta}(z_1) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\ &\times \frac{t_{1m',vis\alpha}}{1 + r_{1m',vis\alpha} r_{m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m',vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\ &\times \frac{t_{1m',jr\beta}}{1 + r_{1m',jr\beta} r_{m',jr\beta} e^{2i\beta_{m',jr} h_{m'}} + (r_{m',jr\beta} + r_{1m',jr\beta} e^{2i\beta_{m',jr} h_{m'}}) r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}} \\ &\times \{(1 + r_{m',vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})(1 + r_{m',jr\beta} r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) \\ &\times \exp[iz_1 (k_{m',vis} \cos\theta_{m',vis} (1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))] \\ &+ (1 + r_{m',vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})(r_{m',jr\beta} + r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',jr} h_{m'}} \\ &\times \exp[iz_1 (k_{m',vis} \cos\theta_{m',vis} (1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (-1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))] \\ &+ (r_{m',vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})(1 + r_{m',jr\beta} r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',vis} h_{m'}} \\ &\times \exp[iz_1 (k_{m',vis} \cos\theta_{m',vis} (-1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))] \\ &+ (r_{m',vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})(r_{m',jr\beta} + r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) e^{2i(\beta_{m',vis} + \beta_{m',jr}) h_{m'}} \\ &\times \exp[iz_1 (k_{m',vis} \cos\theta_{m',vis} (-1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (-1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))]\} \\ &\times \exp[-i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})(k_{m,vis} \sin\theta_{m,vis} + k_{m,jr} \sin\theta_{m,jr})] \end{aligned} \quad (2.13)$$

m 層の m'/m 界面から深さ z_2 の点

$[\mathbf{A}_n^{(m)}]$: E^+ sources

$$\begin{aligned} E_{vis\alpha}(h_m + z_2) &= E_{vis\alpha}^0 \frac{t_{1m',vis\alpha} t_{m',vis\alpha} e^{i\beta_{m',vis} h_{m'}}}{1 + r_{1m',vis\alpha} r_{m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m',vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\ &\times \{\exp[iz_2 k_{m,vis} \cos\theta_{m,vis} (1 + \tan\theta_{m,SF} \tan\theta_{m,vis})] \\ &+ r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m} \exp[iz_2 k_{m,vis} \cos\theta_{m,vis} (-1 + \tan\theta_{m,SF} \tan\theta_{m,vis})]\} \end{aligned}$$

$$\times \exp[-i(2n+2)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})k_{m,vis} \sin\theta_{m,vis}] \quad (2.14a)$$

$$\begin{aligned} E_{ir,\beta}(h_m + z_2) &= E_{ir,\beta}^0 \frac{t_{1m',ir,\beta} t_{m'm,ir,\beta} e^{i\beta_{m',ir} h_{m'}}}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}} \\ &\times \{\exp[iz_2 k_{m,ir} \cos\theta_{m,ir} (1 + \tan\theta_{m,SF} \tan\theta_{m,ir})] \\ &+ r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m} \exp[iz_2 k_{m,ir} \cos\theta_{m,ir} (-1 + \tan\theta_{m,SF} \tan\theta_{m,ir})]\} \\ &\times \exp[-i(2n+2)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})k_{m,ir} \sin\theta_{m,ir}] \end{aligned} \quad (2.14b)$$

$$\begin{aligned} E_{vis\alpha}(h_m + z_2) E_{ir,\beta}(h_m + z_2) &= E_{vis\alpha}^0 E_{ir,\beta}^0 \\ &\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m',vis} h_{m'}}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\ &\times \frac{t_{1m',ir,\beta} t_{m'm,ir,\beta} e^{i\beta_{m',ir} h_{m'}}}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}} \\ &\times \{\exp[iz_2 (k_{m,vis} \cos\theta_{m,vis} (1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (1 + \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\ &+ r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m} \\ &\times \{\exp[iz_2 (k_{m,vis} \cos\theta_{m,vis} (1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (-1 + \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\ &+ r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m} \\ &\times \{\exp[iz_2 (k_{m,vis} \cos\theta_{m,vis} (-1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (1 + \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\ &+ r_{m2,vis\alpha} r_{m2,ir,\beta} e^{2i(\beta_{m,ir} + \beta_{m,vis}) h_m} \\ &\times \{\exp[iz_2 (k_{m,vis} \cos\theta_{m,vis} (-1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (-1 + \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\ &\times \exp[-i(2n+2)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})(k_{m,vis} \sin\theta_{m,vis} + k_{m,ir} \sin\theta_{m,ir})]\} \end{aligned} \quad (2.15)$$

[B_n^(m)]: E⁻ sources

$$\begin{aligned} E_{vis\alpha}(h_m + z_2) &= E_{vis\alpha}^0 \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m',vis} h_{m'}}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\ &\times \{\exp[iz_2 k_{m,vis} \cos\theta_{m,vis} (1 - \tan\theta_{m,SF} \tan\theta_{m,vis})] \\ &+ r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m} \exp[iz_2 k_{m,vis} \cos\theta_{m,vis} (-1 - \tan\theta_{m,SF} \tan\theta_{m,vis})]\} \\ &\times \exp[-i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})k_{m,vis} \sin\theta_{m,vis}] \end{aligned} \quad (2.16a)$$

$$\begin{aligned} E_{ir,\beta}(h_m + z_2) &= E_{ir,\beta}^0 \frac{t_{1m',ir,\beta} t_{m'm,ir,\beta} e^{i\beta_{m',ir} h_{m'}}}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}} \\ &\times \{\exp[iz_2 k_{m,ir} \cos\theta_{m,ir} (1 - \tan\theta_{m,SF} \tan\theta_{m,ir})] \\ &+ r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m} \exp[iz_2 k_{m,ir} \cos\theta_{m,ir} (-1 - \tan\theta_{m,SF} \tan\theta_{m,ir})]\} \\ &\times \exp[-i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})k_{m,ir} \sin\theta_{m,ir}] \end{aligned} \quad (2.16b)$$

$$\begin{aligned}
E_{vis\alpha}(h_m + z_2)E_{ir\beta}(h_m + z_2) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i\beta_{m',vis} h_{m'}}}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
&\times \frac{t_{1m'ir\beta} t_{m'mir\beta} e^{i\beta_{m',ir} h_{m'}}}{1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}} \\
&\times \{ \exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (1 - \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\
&\quad + r_{m2ir\beta} e^{2i\beta_{m,ir} h_m} \\
&\times \{ \exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (-1 - \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\
&\quad + r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m} \\
&\times \{ \exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (-1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (1 - \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\
&\quad + r_{m2vis\alpha} r_{m2ir\beta} e^{2i(\beta_{m,ir} + \beta_{m,vis}) h_m} \\
&\times \{ \exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (-1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,ir} \cos\theta_{m,ir} (-1 - \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\
&\times \exp[-i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})] (k_{m,vis} \sin\theta_{m,vis} + k_{m,ir} \sin\theta_{m,ir}) \} \} \} \quad (2.17)
\end{aligned}$$

2.2. SFG 分極

各部位の SFG 分極は、その部位における vis 光と ir 光の電場積に感受率を掛けたものである。下には、位相を除いた、分極の振幅を示す。

1/m' 界面の 1 側：

(a): E^+ (by reflection and transmission) sources and E^- (for $n = 0$) source

$$\begin{aligned}
P_a^*(0^-) &= \sum_{\alpha,\beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{(1 + r_{1m'vis\alpha}) [(1 + r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_{m'}}) + (r_{m'mvis\alpha} + e^{2i\beta_{m',vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}]}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
&\times \frac{(1 + r_{1m'ir\beta}) [(1 + r_{m'mir\beta} e^{2i\beta_{m',ir} h_{m'}}) + (r_{m'mir\beta} + e^{2i\beta_{m',ir} h_{m'}}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}]}{1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}} \quad (2.18)
\end{aligned}$$

1/m' 界面の m' 側：

(a): E^+ and E^- (by reflection) sources

$$\begin{aligned}
P_a^*(0^+) &= \sum_{\alpha,\beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{t_{1m'vis\alpha} [(1 + r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_{m'}}) + (r_{m'mvis\alpha} + e^{2i\beta_{m',vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}]}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
&\times \frac{t_{1m'ir\beta} [(1 + r_{m'mir\beta} e^{2i\beta_{m',ir} h_{m'}}) + (r_{m'mir\beta} + e^{2i\beta_{m',ir} h_{m'}}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}]}{1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2ir\beta} e^{2i\beta_{m,ir} h_m}} \quad (2.19)
\end{aligned}$$

m/2 界面の 2 側：

(a): E^+ source

$$\begin{aligned}
P_a^*(h_{m'} + h_m^+) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{\text{vis}\alpha} E^0_{\text{ir}\beta} \\
&\times \frac{t_{1m'\text{vis}\alpha} t_{m'm\text{vis}\alpha} t_{m2\text{vis}\alpha} e^{i(\beta_{m'} h_{m'} + \beta_{m'} h_m)}}{1 + r_{1m'\text{vis}\alpha} r_{m'm\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{vis}\alpha} + r_{1m'\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{vis}\alpha} e^{2i\beta_{m'} h_m}} \\
&\times \frac{t_{1m'\text{ir}\beta} t_{m'm\text{ir}\beta} t_{m2\text{ir}\beta} e^{i(\beta_{m'} h_{m'} + \beta_{m'} h_m)}}{1 + r_{1m'\text{ir}\beta} r_{m'm\text{ir}\beta} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{ir}\beta} + r_{1m'\text{ir}\beta} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{ir}\beta} e^{2i\beta_{m'} h_m}}
\end{aligned} \tag{2.20}$$

(b): E^- sources (for $n > 0$, by reflection)

$$\begin{aligned}
P_a^*(h_{m'} + h_m^+) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{\text{vis}\alpha} E^0_{\text{ir}\beta} \\
&\times \frac{t_{1m'\text{vis}\alpha} t_{m'm\text{vis}\alpha} t_{m2\text{vis}\alpha} e^{i(\beta_{m'} h_{m'} + \beta_{m'} h_m)}}{1 + r_{1m'\text{vis}\alpha} r_{m'm\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{vis}\alpha} + r_{1m'\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{vis}\alpha} e^{2i\beta_{m'} h_m}} \\
&\times \frac{t_{1m'\text{ir}\beta} t_{m'm\text{ir}\beta} t_{m2\text{ir}\beta} e^{i(\beta_{m'} h_{m'} + \beta_{m'} h_m)}}{1 + r_{1m'\text{ir}\beta} r_{m'm\text{ir}\beta} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{ir}\beta} + r_{1m'\text{ir}\beta} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{ir}\beta} e^{2i\beta_{m'} h_m}}
\end{aligned} \tag{2.21}$$

$m/2$ 界面の m 側 :

(a): E^+ (by reflection) and E^- sources

$$\begin{aligned}
P_a^*(h_{m'} + h_m^-) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{\text{vis}\alpha} E^0_{\text{ir}\beta} \\
&\times \frac{t_{1m'\text{vis}\alpha} t_{m'm\text{vis}\alpha} (1 + r_{m2\text{vis}\alpha}) e^{i(\beta_{m'} h_{m'} + \beta_{m'} h_m)}}{1 + r_{1m'\text{vis}\alpha} r_{m'm\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{vis}\alpha} + r_{1m'\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{vis}\alpha} e^{2i\beta_{m'} h_m}} \\
&\times \frac{t_{1m'\text{ir}\beta} t_{m'm\text{ir}\beta} (1 + r_{m2\text{ir}\beta}) e^{i(\beta_{m'} h_{m'} + \beta_{m'} h_m)}}{1 + r_{1m'\text{ir}\beta} r_{m'm\text{ir}\beta} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{ir}\beta} + r_{1m'\text{ir}\beta} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{ir}\beta} e^{2i\beta_{m'} h_m}}
\end{aligned} \tag{2.22}$$

m'/m 界面の m' 側 :

(a): E^+ and E^- (by reflection) sources

$$\begin{aligned}
P_a^*(h_m^-) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{\text{vis}\alpha} E^0_{\text{ir}\beta} \\
&\times \frac{t_{1m'\text{vis}\alpha} e^{i\beta_{m'} h_{m'}} (1 + r_{m'm\text{vis}\alpha}) (1 + r_{m2\text{vis}\alpha} e^{2i\beta_{m'} h_m})}{1 + r_{1m'\text{vis}\alpha} r_{m'm\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{vis}\alpha} + r_{1m'\text{vis}\alpha} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{vis}\alpha} e^{2i\beta_{m'} h_m}} \\
&\times \frac{t_{1m'\text{ir}\beta} e^{i\beta_{m'} h_{m'}} (1 + r_{m'm\text{ir}\beta}) (1 + r_{m2\text{ir}\beta} e^{2i\beta_{m'} h_m})}{1 + r_{1m'\text{ir}\beta} r_{m'm\text{ir}\beta} e^{2i\beta_{m'} h_{m'}} + (r_{m'm\text{ir}\beta} + r_{1m'\text{ir}\beta} e^{2i\beta_{m'} h_{m'}}) r_{m2\text{ir}\beta} e^{2i\beta_{m'} h_m}}
\end{aligned} \tag{2.23}$$

(b): E^+ (by reflection) and E^- sources

$$P_a^*(h_m^-) = \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{\text{vis}\alpha} E^0_{\text{ir}\beta}$$

$$\begin{aligned}
& \times \frac{t_{1m',vis\alpha} e^{i\beta_{m',vis} h_m} (1 + r_{m'm,vis\alpha}) (1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_m} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_m}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
& \times \frac{t_{1m',ir\beta} e^{i\beta_{m',ir} h_m} (1 + r_{m'm,ir\beta}) (1 + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_m} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_m}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}}
\end{aligned} \tag{2.24}$$

m'/m 界面の m 側：

(a): E^+ and E^- (by reflection) sources

$$\begin{aligned}
P_a^* (h_m^+) &= \sum_{\alpha,\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m',vis} h_m} (1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_m} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_m}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
& \times \frac{t_{1m',ir\beta} t_{m'm,ir\beta} e^{i\beta_{m',ir} h_m} (1 + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_m} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_m}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}}
\end{aligned} \tag{2.25}$$

(b): E^+ (by reflection) and E^- sources

$$\begin{aligned}
P_a^* (h_m^+) &= \sum_{\alpha,\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m',vis} h_m} (1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_m} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_m}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
& \times \frac{t_{1m',ir\beta} t_{m'm,ir\beta} e^{i\beta_{m',ir} h_m} (1 + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_m} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_m}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}}
\end{aligned} \tag{2.26}$$

m' 層の深さ z_1 点：

$[A_n^{(m')}]$: E^+ sources

$$\begin{aligned}
P_a^* (z_1) &= \sum_{\alpha,\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m',vis\alpha}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_m} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_m}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
& \times \frac{t_{1m',ir\beta}}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_m} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_m}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}} \\
& \times \{(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m})\} \\
& \times \exp[i z_1 (k_{m',vis} \cos \theta_{m',vis} (1 + \tan \theta_{m',SF} \tan \theta_{m',vis}) + k_{m',ir} \cos \theta_{m',ir} (1 + \tan \theta_{m',SF} \tan \theta_{m',ir}))] \\
& + (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',ir} h_m} \\
& \times \exp[i z_1 (k_{m',vis} \cos \theta_{m',vis} (1 + \tan \theta_{m',SF} \tan \theta_{m',vis}) + k_{m',ir} \cos \theta_{m',ir} (-1 + \tan \theta_{m',SF} \tan \theta_{m',ir}))] \\
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',vis} h_m} \\
& \times \exp[i z_1 (k_{m',vis} \cos \theta_{m',vis} (-1 + \tan \theta_{m',SF} \tan \theta_{m',vis}) + k_{m',ir} \cos \theta_{m',ir} (1 + \tan \theta_{m',SF} \tan \theta_{m',ir}))]
\end{aligned}$$

$$\begin{aligned}
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'm,jr,\beta} + r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_m} \\
& \times \exp[iz_1(k_{m',vis} \cos\theta_{m',vis} (-1 + \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (-1 + \tan\theta_{m',SF} \tan\theta_{m',jr}))]
\end{aligned} \tag{2.27}$$

[B_n^(m')]: E⁻ sources

$$\begin{aligned}
P_a^*(z_1) &= \sum_{\alpha,\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir,\beta}^0 \\
& \times \frac{t_{1m',vis\alpha}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_m} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_m}) r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m}} \\
& \times \frac{t_{1m',jr,\beta}}{1 + r_{1m',jr,\beta} r_{m'm,jr,\beta} e^{2i\beta_{m',ir}h_m} + (r_{m'm,jr,\beta} + r_{1m',jr,\beta} e^{2i\beta_{m',ir}h_m}) r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}} \\
& \times \{(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(1 + r_{m'm,jr,\beta} r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}) \\
& \times \exp[iz_1(k_{m',vis} \cos\theta_{m',vis} (1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))] \\
& + (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'm,jr,\beta} + r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',ir}h_m} \\
& \times \exp[iz_1(k_{m',vis} \cos\theta_{m',vis} (1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (-1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))] \\
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(1 + r_{m'm,jr,\beta} r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',vis}h_m} \\
& \times \exp[iz_1(k_{m',vis} \cos\theta_{m',vis} (-1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))] \\
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'm,jr,\beta} + r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_m} \\
& \times \exp[iz_1(k_{m',vis} \cos\theta_{m',vis} (-1 - \tan\theta_{m',SF} \tan\theta_{m',vis}) + k_{m',jr} \cos\theta_{m',jr} (-1 - \tan\theta_{m',SF} \tan\theta_{m',jr}))]
\end{aligned} \tag{2.28}$$

m 層 の m'/m 界面から深さ z₂ の点 :

[A_n^(m)]: E⁺ sources

$$\begin{aligned}
P_a^*(z_2) &= \sum_{\alpha,\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir,\beta}^0 \\
& \times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m',vis}h_m}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_m} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_m}) r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m}} \\
& \times \frac{t_{1m',jr,\beta} t_{m'm,jr,\beta} e^{i\beta_{m',ir}h_m}}{1 + r_{1m',jr,\beta} r_{m'm,jr,\beta} e^{2i\beta_{m',ir}h_m} + (r_{m'm,jr,\beta} + r_{1m',jr,\beta} e^{2i\beta_{m',ir}h_m}) r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (1 + \tan\theta_{m,SF} \tan\theta_{m,jr}))] \\
& + r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (-1 + \tan\theta_{m,SF} \tan\theta_{m,jr}))] \\
& + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (-1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (1 + \tan\theta_{m,SF} \tan\theta_{m,jr}))]
\end{aligned}$$

$$\begin{aligned}
& + r_{m2,vis\alpha} r_{m2,jr,\beta} e^{2i(\beta_{m,jr} + \beta_{m,vis})h_m} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (-1 + \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (-1 + \tan\theta_{m,SF} \tan\theta_{m,jr}))]\} \\
\end{aligned} \tag{2.29}$$

[B_n^(m)]: E⁻ sources

$$\begin{aligned}
P_a^*(z_2) &= \sum_{\alpha,\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir,\beta}^0 \\
& \times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m',vis}h_{m'}}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}} \\
& \times \frac{t_{1m',jr,\beta} t_{m'm,jr,\beta} e^{i\beta_{m',jr}h_{m'}}}{1 + r_{1m',jr,\beta} r_{m'm,jr,\beta} e^{2i\beta_{m',jr}h_{m'}} + (r_{m'm,jr,\beta} + r_{1m',jr,\beta} e^{2i\beta_{m',jr}h_{m'}}) r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m}} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (1 - \tan\theta_{m,SF} \tan\theta_{m,jr}))]\} \\
& + r_{m2,jr,\beta} e^{2i\beta_{m,ir}h_m} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (-1 - \tan\theta_{m,SF} \tan\theta_{m,jr}))]\} \\
& + r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (-1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (1 - \tan\theta_{m,SF} \tan\theta_{m,jr}))]\} \\
& + r_{m2,vis\alpha} r_{m2,jr,\beta} e^{2i(\beta_{m,jr} + \beta_{m,vis})h_m} \\
& \times \{\exp[iz_2(k_{m,vis} \cos\theta_{m,vis} (-1 - \tan\theta_{m,SF} \tan\theta_{m,vis}) + k_{m,jr} \cos\theta_{m,jr} (-1 - \tan\theta_{m,SF} \tan\theta_{m,jr}))]\} \tag{2.30}
\end{aligned}$$

2.3. SFG 電場

別ファイル「二層膜からの和周波 (SFG) — 一般式」に記した結果を使って、以下の表式を導く。なお、位相部分については結果だけを記す。

1/m' 界面の 1 側の分極からの SFG :

(a): 反射方向

ゼロ次光による $E(0^+) + r_{1m}E^+(0)$ に加えて、内部に進入した光が多重反射して出てきたもの、即ち、ファイル「二層膜からの和周波 (SFG) — 一般式」(以後ファイル「一般式」と略記する)の (2.1) 式において $L_{m/m}^+P(z_1)$ を $t_{1m}L_{1/l}^+P(z_1 = 0)$ に置き換えたものが加わる。 $a_0^* = a$ 、 $a_0 = 1$ であるから、下式のようにになる。

$$\begin{aligned}
E_{-1}(0^-)_{net} &= \{L_{-1/l}^- + L_{1/l}^+[r_{1m'} + \frac{t_{1m}t_{m1}(r_{m'm} + r_{m2}b^2)a^2}{1 + r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2}]\} P^*(z_1 = 0) \\
&= \frac{(L_{-1/l}^- + r_{1m'}L_{1/l}^+)(1 + r_{m'm}r_{m2}b^2) + (r_{1m'}L_{-1/l}^- + L_{1/l}^+)(r_{m'm} + r_{m2}b^2)a^2}{1 + r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2} P^*(z_1 = 0)
\end{aligned}$$

ここで、

$$\begin{aligned}
(L_{-1/l,px}^- + r_{1m',p}L_{1/l,px}^+) &= (r_{1m',p}L_{-1/l,px}^- + L_{1/l,px}^+) = L_{-1/m',px}^- \\
(L_{-1/l,sy}^- + r_{1m',s}L_{1/l,sy}^+) &= (r_{1m',s}L_{-1/l,sy}^- + L_{1/l,sy}^+) = L_{-1/m',sy}^- \\
(L_{-1/l,pz}^- + r_{1m',p}L_{1/l,pz}^+) &= -(r_{1m',p}L_{-1/l,pz}^- + L_{1/l,pz}^+) = L_{-1/m',pz}^- \quad (n_m = n_1)
\end{aligned}$$

であるから、

$$E^-_1(0^-)_{net} = \frac{(1 + r_{m'm}r_{m2}b^2) \pm (r_{m'm} + r_{m2}b^2)a^2}{1 + r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} L^-_{1/m} P^* (z_1 = 0)$$

(upper sign for x and y, lower sign for z)

(2.18) 式により、

$$E^-_1(0^-)_{net,p} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{(1 + r_{1m',vis\alpha})(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) + (r_{m'm,vis\alpha} + e^{2\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}$$

$$\times \frac{(1 + r_{1m',ir,\beta})(1 + r_{m'm,ir,\beta} e^{2\beta_{m',ir}h_{m'}}) + (r_{m'm,ir,\beta} + e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2\beta_{m',ir}h_{m'}})r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}}$$

$$\times \left[\frac{(1 + r_{m'm,SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) + (r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m})e^{2i\beta_{m,SF}h_m}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2\beta_{m',SF}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2\beta_{m',SF}h_{m'}})r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}} L^-_{1/m',px} \chi_{\alpha\beta} \right.$$

$$\left. + \frac{(1 + r_{m'm,SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) - (r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m})e^{2i\beta_{m,SF}h_m}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2\beta_{m',SF}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2\beta_{m',SF}h_{m'}})r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}} L^-_{1/m',pz} \chi_{\alpha\beta} \right] \quad (n_m = n_1)$$

(2.31a)

$$E^-_1(0^-)_{net,s} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{(1 + r_{1m',vis\alpha})(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) + (r_{m'm,vis\alpha} + e^{2\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}$$

$$\times \frac{(1 + r_{1m',ir,\beta})(1 + r_{m'm,ir,\beta} e^{2\beta_{m',ir}h_{m'}}) + (r_{m'm,ir,\beta} + e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2\beta_{m',ir}h_{m'}})r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}}$$

$$\times \frac{(1 + r_{m'm,SF,s} r_{m2,SF,s} e^{2i\beta_{m,SF}h_m}) + (r_{m'm,SF,s} + r_{m2,SF,s} e^{2i\beta_{m,SF}h_m})e^{2\beta_{m,SF}h_m}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2\beta_{m',SF}h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2\beta_{m',SF}h_{m'}})r_{m2,SF,s} e^{2i\beta_{m,SF}h_m}} L^-_{1/m',sy} \chi_{\alpha\beta}$$

(2.31b)

(b): 透過方向

$E^+(0)$ だけが膜内部に進入して反対側に抜ける。上と同様に、ファイル「一般式」の (2.2) 式において $L^+_{m'/m}P(z_1)$ を $t_{1m}L^+_{1/1}P(z_1 = 0)$ に置き換え、 $a_0^* = a$ 、 $a_0 = 1$ として、下式が得られる。

$$E^+_2(h_m^+)_{net} = \frac{t_{1m}t_{m2}t_{m'm}ab}{1 + r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} L^+_{1/1} P^* (z_1 = 0)$$

ここで、

$$t_{1m',p} L^+_{1/1,px} = L^+_{1/m',px},$$

$$t_{1m',s} L^+_{1/1,sy} = L^+_{1/m',sy},$$

$$t_{1m',p} L^+_{1/1,pz} = L^+_{1/m',pz} \quad (n_m = n_1)$$

であるから、

$$E_{net}^{+2}(h_m^+) = \frac{t_{m'm} t_{m2} ab}{1 + r_{1m} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} L^{+1/m'} P^* (z_1 = 0)$$

(2.18) 式により、

$$\begin{aligned} E_{net,p}^{+2}(h_m^+) &= \sum_{\alpha,\beta} E_{vis\alpha}^0 E_{ir,\beta}^0 \\ &\times \frac{(1 + r_{1m',vis\alpha}) [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) + (r_{m'm,vis\alpha} + e^{2\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m}]}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m}} \\ &\times \frac{(1 + r_{1m',ir,\beta}) [(1 + r_{m'm,ir,\beta} e^{2\beta_{m',ir} h_{m'}}) + (r_{m'm,ir,\beta} + e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m',ir} h_m}]}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m',ir} h_m}} \\ &\times \frac{t_{1m',SF,p} t_{m2,SF,p} e^{i(\beta_{\beta m, SF} h_m + \beta_{m', SF} h_{m'})} (L^{+1/m',px} \chi_{\alpha\alpha\beta} + L^{+1/m',pz} \chi_{\alpha\alpha\beta})}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2\beta_{m',SF} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m',SF} h_m}} \quad (n_m = n_1) \end{aligned} \quad (2.32a)$$

$$\begin{aligned} E_{net,s}^{+2}(h_m^+) &= \sum_{\alpha,\beta} E_{vis\alpha}^0 E_{ir,\beta}^0 \\ &\times \frac{(1 + r_{1m',vis\alpha}) [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) + (r_{m'm,vis\alpha} + e^{2\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m}]}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m}} \\ &\times \frac{(1 + r_{1m',ir,\beta}) [(1 + r_{m'm,ir,\beta} e^{2\beta_{m',ir} h_{m'}}) + (r_{m'm,ir,\beta} + e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m',ir} h_m}]}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m',ir} h_m}} \\ &\times \frac{t_{1m',SF,s} t_{m2,SF,s} e^{i(\beta_{\beta m, SF} h_m + \beta_{m', SF} h_{m'})} L^{+1/m',sy} \chi_{\alpha\alpha\beta}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2\beta_{m',SF} h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF} h_{m'}}) r_{m2,SF,s} e^{2\beta_{m',SF} h_m}} \end{aligned} \quad (2.32b)$$

1/m' 界面の m' 側の分極からの SFG :

(a): 反射方向

ファイル「一般式」の (2.1) 式と (2.3) 式において、 $z_1 = 0$ 、 $a_0^* = a$ 、 $a_0 = 1$ とする。

$$E_{net}^{-1}(0^-) = \frac{t_{m1} [(r_{m'm} + r_{m2} b^2) a^2 L^{+1/m'} + (1 + r_{m'm} r_{m2} b^2) L^{-1/m'}]}{1 + r_{1m} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} P^* (z_1 = 0)$$

ここで、

$$\begin{aligned} t_{1m',p} L^{+1/m',px} &= t_{1m',p} L^{-1/m',px}, \\ t_{1m',s} L^{+1/m',sy} &= t_{1m',s} L^{-1/m',sy}, \\ t_{1m',p} L^{+1/m',pz} &= -t_{1m',p} L^{-1/m',pz} \quad (n_m = n_m) \end{aligned}$$

であるから、

$$E^{-1}(0^-)_{net} = \frac{t_{m1} [(1 + r_{m'm} r_{m2} b^2) \pm (r_{m'm} + r_{m2} b^2) a^2]}{1 + r_{1m} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} L^{-1/m'} P^* (z_1 = 0)$$

(upper sign for x and y, lower sign for z)

(2.19) 式により、

$$E^{-1}(0^-)_{net,p} = \sum_{\alpha, \beta} E^{0,vis\alpha} E^{0,ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) + (r_{m'm,vis\alpha} + e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}]}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir,\beta} [(1 + r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) + (r_{m'm,ir,\beta} + e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}]}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \left[\frac{(1 + r_{m'm,SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) + (r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}}}{1 + r_{1m,SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}} L^{-1/m',pz} \chi_{\alpha\beta} \right.$$

$$\left. + \frac{(1 + r_{m'm,SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) - (r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}} L^{-1/m',pz} \chi_{\alpha\beta} \right] \quad (n_{m'} = n_m)$$

(2.33a)

$$E^{-1}(0^-)_{net,s} = \sum_{\alpha, \beta} E^{0,vis\alpha} E^{0,ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) + (r_{m'm,vis\alpha} + e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}]}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir,\beta} [(1 + r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) + (r_{m'm,ir,\beta} + e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}]}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \frac{(1 + r_{m'm,SF,s} r_{m2,SF,s} e^{2i\beta_{m,SF} h_m}) + (r_{m'm,SF,s} + r_{m2,SF,s} e^{2i\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}}}{1 + r_{1m,SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF} h_{m'}}) r_{m2,SF,s} e^{2i\beta_{m,SF} h_m}} L^{-1/m',sy} \chi_{\alpha\beta}$$

(2.33b)

(b): 透過方向

ファイル「一般式」の (2.2) 式と (2.4) 式において、 $z_1 = 0$ 、 $a_0^* = a$ 、 $a_0 = 1$ とすると、下式が得られる。

$$E^{+2}(h_{m'} + h_m^+)_{net} = \frac{t_{m2} ab [t_{m'm}^+ L^{m'/m'} + r_{m1} t_{m'm}^- L^{-m'/m'}]}{1 + r_{1m} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} P^* (z_1 = 0)$$

ここで、

$$t_{m'm,p}^+ L^{m'/m',px} = t_{m'm,p}^- L^{-m'/m',px} = L^{m'/m,px},$$

$$t_{m'm,s}^+ L^{m'/m',sy} = t_{m'm,s}^- L^{-m'/m',sy} = L^{m'/m,sy},$$

$$t_{m'm,p}^+ L^{m'/m',pz} = -t_{m'm,p}^- L^{-m'/m',pz} = L^{m'/m,pz} \quad (n_{m'} = n_m)$$

であるから、

$$E^+_2(h_m^- + h_m^+)_{net} = \frac{t_{m2}ab(1 \pm r_{m1})}{1 + r_{1m}r_{m'm}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} L^- m' / m P^* (z_1 = 0)$$

(upper sign for x and y, lower sign for z)

(2.19) 式により、

$$E^+_2(h_m^- + h_m^+)_{net,p} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir\beta}$$

$$\times \frac{t_{1m',vis\alpha} [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) + (r_{m'm,vis\alpha} + e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}]}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}$$

$$\times \frac{t_{1m',ir\beta} [(1 + r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}}) + (r_{m'm,ir\beta} + e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}]}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}}$$

$$\times \frac{e^{i(\beta_{\beta m, SF}h_m + \beta_{m', SF}h_{m'})} [(1 + r_{m1,SF,p})L^+_{m'/m,px} \chi_{x\alpha\beta} + (1 - r_{m1,SF,p})L^+_{m'/m,pz} \chi_{z\alpha\beta}]}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}} \quad (n_m^n = n_m) \quad (2.34a)$$

$$E^+_2(h_m^- + h_m^+)_{net,s} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir\beta}$$

$$\times \frac{t_{1m',vis\alpha} [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) + (r_{m'm,vis\alpha} + e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}]}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}$$

$$\times \frac{t_{1m',ir\beta} [(1 + r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}}) + (r_{m'm,ir\beta} + e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}]}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}}$$

$$\times \frac{e^{i(\beta_{\beta m, SF}h_m + \beta_{m', SF}h_{m'})} (1 + r_{m1,SF,s})L^+_{m'/m,sy} \chi_{y\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}} \quad (2.34b)$$

m/2 界面の 2 側の分極からの SFG :

(a): 反射方向

$E(h_m^+)$ だけが膜内に進入して反対側に抜ける。ファイル「一般式」の (2.7) 式において、 $z_2 = h_m$ 、 $b_0^* = 1$ 、 $b_0 = b$ とする。

$$E^-_1(0^-)_{net} = \frac{t_{2m}t_{m1}b^2(r_{m'm} + r_{1m}a^2)L^-_{2/2}}{1 + r_{1m}r_{m'm}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^* (z_2 = h_m^+)$$

ここで、

$$t_{2m,p}L^-_{2/2,px} = L^-_{m/2,px},$$

$$t_{2m,s}L^-_{2/2,sy} = L^-_{m/2,sy},$$

$$t_{2m,p}L^-_{2/2,pz} = L^-_{m/2,pz} \quad (n_m^n = n_2)$$

であるから、

$$E^-_{1}(0^-)_{net} = \frac{t_{m1}b^2(r_{m'm} + r_{1m}a^2)L^-_{m/2}}{1 + r_{1m}r_{m'm}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^*(z_2 = h_m^+)$$

(2.20) 式を参照して、

$$\begin{aligned} E^-_{1p}(0^-)_{net} &= \sum_{\alpha, \beta} E^0_{vis\alpha} E^0_{ir, \beta} \\ &\times \frac{t_{1m'vis\alpha} t_{mm'vis\alpha} t_{m2vis\alpha} e^{i(\beta_{m',vis}h_{m'} + \beta_{m,vis}h_m)}}{1 + r_{1m'vis\alpha} r_{m'm'vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm'vis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis}h_m}} \\ &\times \frac{t_{1m'ir, \beta} t_{m'm'ir, \beta} t_{m2ir, \beta} e^{i(\beta_{m',ir}h_{m'} + \beta_{m,ir}h_m)}}{1 + r_{1m'ir, \beta} r_{m'm'ir, \beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm'ir, \beta} + r_{1m'ir, \beta} e^{2i\beta_{m',ir}h_{m'}}) r_{m2ir, \beta} e^{2i\beta_{m,ir}h_m}} \\ &\times \frac{t_{2mSF,p} t_{m1SF,p} e^{2i\beta_{m,SF}h_m} (r_{m'mSF,p} + r_{1m'SF,p} e^{2i\beta_{m,SF}h_m}) [L^-_{m/2,px} \chi_{x\alpha\beta} + L^-_{m/2,pz} \chi_{z\alpha\beta}]}{1 + r_{1m'SF,p} r_{m'mSF,p} e^{2i\beta_{m,SF}h_m} + (r_{m'mSF,p} + r_{1m'SF,p} e^{2i\beta_{m,SF}h_m}) r_{m2SF,p} e^{2i\beta_{m,SF}h_m}} \quad (n_m = n_2) \quad (2.35a) \end{aligned}$$

$$\begin{aligned} E^-_{1s}(0^-)_{net} &= \sum_{\alpha, \beta} E^0_{vis\alpha} E^0_{ir, \beta} \\ &\times \frac{t_{1m'vis\alpha} t_{mm'vis\alpha} t_{m2vis\alpha} e^{i(\beta_{m',vis}h_{m'} + \beta_{m,vis}h_m)}}{1 + r_{1m'vis\alpha} r_{m'm'vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm'vis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis}h_m}} \\ &\times \frac{t_{1m'ir, \beta} t_{m'm'ir, \beta} t_{m2ir, \beta} e^{i(\beta_{m',ir}h_{m'} + \beta_{m,ir}h_m)}}{1 + r_{1m'ir, \beta} r_{m'm'ir, \beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm'ir, \beta} + r_{1m'ir, \beta} e^{2i\beta_{m',ir}h_{m'}}) r_{m2ir, \beta} e^{2i\beta_{m,ir}h_m}} \\ &\times \frac{t_{2mSF,s} t_{m1SF,s} (r_{m'mSF,s} + r_{1m'SF,s} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m,SF}h_m} L^-_{m/2,sy} \chi_{y\alpha\beta}}{1 + r_{1m'SF,p} r_{m'mSF,p} e^{2i\beta_{m,SF}h_m} + (r_{m'mSF,p} + r_{1m'SF,p} e^{2i\beta_{m,SF}h_m}) r_{m2SF,p} e^{2i\beta_{m,SF}h_m}} \quad (2.35b) \end{aligned}$$

(b): 透過方向

ゼロ次光による $E^+(z_2 = h_m^+) + r_{2m} E^-(z_2 = h_m^+)$ に加えて、内部に進入した光が多重反射して出てきたもの、即ち、ファイル「一般式」の (2.8) 式において $L^-_{mm}P(z_2)$ を $t_{1m}L^-_{2/2}P(z_2 = h_m^+)$ に置き換えたものが加わる。また、ファイル「一般式」の (2.8) 式において、 $z_2 = h_m$ 、 $b_0^* = 1$ 、 $b_0 = b$ とする。

$$\begin{aligned} E^+_{2}(h_m + h_m^+)_{net} &= \left\{ L^+_{2/2} + L^-_{2/2} [r_{2m} - \frac{t_{2m}t_{m2}b^2(r_{m'm} + r_{1m}a^2)}{1 + r_{1m}r_{m'm}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2}] \right\} P^*(z_2 = h_m^+) \\ &= \frac{(1 + r_{1m}r_{m'm}a^2)(L^+_{2/2} + r_{2m}L^-_{2/2}) + (r_{m'm} + r_{1m}a^2)b^2(r_{m2}L^+_{2/2} + L^-_{2/2})}{1 + r_{1m}r_{m'm}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^*(z_2 = h_m^+) \end{aligned}$$

ここで、

$$\begin{aligned} (L^+_{2/2,px} + r_{2m,p}L^-_{2/2,px}) &= (r_{m2,p}L^+_{2/2,px} + L^-_{2/2,px}) = L^+_{2/m,px} \\ (L^+_{2/2,sy} + r_{2m,s}L^-_{2/2,sy}) &= (r_{m2,s}L^+_{2/2,sy} + L^-_{2/2,sy}) = L^+_{2/m,sy} \\ (L^+_{2/2,pz} + r_{2m,p}L^-_{2/2,pz}) &= -(r_{m2,p}L^+_{2/2,pz} + L^-_{2/2,pz}) = L^+_{2/m,pz} \quad (n_m = n_2) \end{aligned}$$

であるから、

$$E_{2}^{+}(h_{m'} + h_{m}^{+})_{net} = \frac{(1 + r_{1m'}r_{m'm}a^2) \pm (r_{m'm} + r_{1m'}a^2)b^2}{1 + r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2} L_{2/m}^{+} P^{*} (z_2 = h_{m}^{+})$$

(upper sign for x and y, lower sign for z)

(2.20) 式を参照して、

$$E_{2,p}^{+}(h_{m'} + h_{m}^{+})_{net} = \sum_{\alpha,\beta} E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} t_{m2,vis\alpha} e^{i(\beta_{m',vis}h_{m'} + \beta_{m,vis}h_m)}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}$$

$$\times \frac{t_{1m',ir\beta} t_{m'm,ir\beta} t_{m2,ir\beta} e^{i(\beta_{m',ir}h_{m'} + \beta_{m,ir}h_m)}}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir}h_{m'}}) r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}}$$

$$\times \left\{ \frac{[(1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p}h_{m'}}) + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p}h_{m'}}) e^{2i\beta_{m,SF,p}h_m}] L_{2/m,p}^{-} \chi_{x\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p}h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF,p}h_m}} \right.$$

$$\left. + \frac{[(1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p}h_{m'}}) - (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p}h_{m'}}) e^{2i\beta_{m,SF,p}h_m}] L_{2/m,p}^{-} \chi_{z\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p}h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF,p}h_m}} \right\} \quad (n_m = n_2) \quad (2.36a)$$

$$E_{2,s}^{+}(h_{m'} + h_{m}^{+})_{net} = \sum_{\alpha,\beta} E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} t_{m2,vis\alpha} e^{i(\beta_{m',vis}h_{m'} + \beta_{m,vis}h_m)}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}$$

$$\times \frac{t_{1m',ir\beta} t_{m'm,ir\beta} t_{m2,ir\beta} e^{i(\beta_{m',ir}h_{m'} + \beta_{m,ir}h_m)}}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir}h_{m'}}) r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}}$$

$$\times \frac{[(1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF,s}h_{m'}}) + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF,s}h_{m'}}) e^{2i\beta_{m,SF,s}h_m}] L_{2/m,s}^{-} \chi_{y\alpha\beta}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF,s}h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF,s}h_{m'}}) r_{m2,SF,s} e^{2i\beta_{m,SF,s}h_m}} \quad (2.36b)$$

m/2 界面の m 側の分極からの SFG :

(a): 反射方向

ファイル「一般式」の (2.5) 式と (2.7) 式において、 $z_2 = h_m$ 、 $b_0^* = 1$ 、 $b_0 = b$ とする。

$$E_{1}^{-}(0^{-})_{net} = \frac{abt_{mm'}(r_{m2}L_{m/m}^{+} + L_{m/m}^{-})}{1 + r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2} P^{*} (z_2 = h_m^{-})$$

ここで、

$$t_{mm',p}L_{m/m,px}^{+} = t_{mm',p}L_{m/m,px}^{-} = L_{m'/m,px}^{-},$$

$$t_{mm',s}L_{m/m,sy}^{+} = t_{mm',s}L_{m/m,sy}^{-} = L_{m'/m,sy}^{-},$$

$$t_{mm',p}L_{m/m,pz}^{+} = t_{mm',p}L_{m/m,pz}^{-} = -L_{m'/m,px}^{-} \quad (n_m = n_m)$$

であるから、

$$E^{-1}(0^-)_{net} = \frac{ab(1 \pm r_{m2})L^{-m'/m}}{1 + r_{1m}r_{m2}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^* (z_2 = h_m^-)$$

(upper sign for x and y components, lower sign for z component)

(2.23) 式を参照して、

$$E^{-1p}(0^-)_{net} = \sum_{\alpha, \beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m';vis} h_m'} (1 + r_{m'm,vis\alpha}) (1 + r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m';vis} h_m'} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_m'}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m}}$$

$$\times \frac{t_{1m',jr,\beta} e^{i\beta_{m';jr} h_m'} (1 + r_{m'm,jr,\beta}) (1 + r_{m2,jr,\beta} e^{2i\beta_{m',jr} h_m})}{1 + r_{1m',jr,\beta} r_{m'm,jr,\beta} e^{2i\beta_{m';jr} h_m'} + (r_{m'm,jr,\beta} + r_{1m',jr,\beta} e^{2i\beta_{m',jr} h_m'}) r_{m2,jr,\beta} e^{2i\beta_{m',jr} h_m}}$$

$$\times \frac{e^{i(\beta_{m',SF,p} h_m + \beta_{m,SF,p} h_m)} [(1 + r_{m2,SF,p}) L^{-m'/m,px} \chi_{\alpha\beta} + (1 - r_{m2,SF,p}) L^{-m'/m,pz} \chi_{\alpha\beta}]}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p} h_m'} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p} h_m'}) r_{m2,SF,p} e^{2i\beta_{m',SF,p} h_m}} \quad (n_m'' = n_m) \quad (2.37a)$$

$$E^{-1s}(0^-)_{net} = \sum_{\alpha, \beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m';vis} h_m'} (1 + r_{m'm,vis\alpha}) (1 + r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m';vis} h_m'} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_m'}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_m}}$$

$$\times \frac{t_{1m',jr,\beta} e^{i\beta_{m';jr} h_m'} (1 + r_{m'm,jr,\beta}) (1 + r_{m2,jr,\beta} e^{2i\beta_{m',jr} h_m})}{1 + r_{1m',jr,\beta} r_{m'm,jr,\beta} e^{2i\beta_{m';jr} h_m'} + (r_{m'm,jr,\beta} + r_{1m',jr,\beta} e^{2i\beta_{m',jr} h_m'}) r_{m2,jr,\beta} e^{2i\beta_{m',jr} h_m}}$$

$$\times \frac{e^{i(\beta_{m',SF,s} h_m + \beta_{m,SF,s} h_m)} (1 + r_{m2,SF,s}) L^{-m'/m,sy} \chi_{\alpha\beta}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF,s} h_m'} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF,s} h_m'}) r_{m2,SF,s} e^{2i\beta_{m',SF,s} h_m}} \quad (2.37b)$$

(b): 透過方向

ファイル「一般式」の (2.6) 式と (2.8) 式において、 $z_2 = h_m$ 、 $b_0^* = 1$ 、 $b_0 = b$ とする。

$$E^{+2}(h_m^-, h_m^+)_{net} = \frac{(1 + r_{1m}r_{m2}a^2)L^{+m/m} - (r_{m'm} + r_{1m}a^2)b^2L^{-m/m}}{1 + r_{1m}r_{m2}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^* (z_2 = h_m^-)$$

ここで、

$$t_{m2,p} L^{+m/m,px} = t_{m2,p} L^{-m/m,px} = L^{+m/2,px},$$

$$t_{m2,s} L^{+m/m,sy} = t_{m2,s} L^{-m/m,sy} = L^{+m/2,sy},$$

$$t_{m2,p} L^{+m/m,pz} = -t_{m2,p} L^{-m/m,pz} = L^{+m/2,pz} \quad (n_m'' = n_m)$$

であるから、

$$E_{2,p}^+(h_{m'} + h_m^+)_{net} = \frac{[(1 + r_{1m'} r_{m'm} a^2) m (r_{m'm} + r_{1m} a^2) b^2] L_{m/2}^+}{1 + r_{1m'} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} P^* (z_2 = h_m^-)$$

(upper sign for x and y components, lower sign for z component)

(2.23) 式を参照して、

$$E_{2,p}^+(h_{m'} + h_m^+)_{net} = \sum_{\alpha, \beta} E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m',vis} h_{m'}} (1 + r_{m'm,vis\alpha}) (1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir\beta} e^{i\beta_{m',ir} h_{m'}} (1 + r_{m'm,ir\beta}) (1 + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \left\{ \frac{[(1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) - (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) e^{2i\beta_{m,SF,p} h_m}] L_{m/2,px}^+ \chi_{x\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF,p} h_m}} \right.$$

$$\left. + \frac{[(1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) e^{2i\beta_{m,SF,p} h_m}] L_{m/2,pz}^+ \chi_{z\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF,p} h_m}} \right\} \quad (n_m^+ = n_m)$$

(2.38a)

$$E_{2,s}^+(h_{m'} + h_m^+)_{net} = \sum_{\alpha, \beta} E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m',vis} h_{m'}} (1 + r_{m'm,vis\alpha}) (1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir\beta} e^{i\beta_{m',ir} h_{m'}} (1 + r_{m'm,ir\beta}) (1 + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \frac{[(1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF,s} h_{m'}}) - (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF,s} h_{m'}}) e^{2i\beta_{m,SF,s} h_m}] L_{m/2,sy}^+ \chi_{y\alpha\beta}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF,s} h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF,s} h_{m'}}) r_{m2,SF,s} e^{2i\beta_{m,SF,s} h_m}}$$

(2.38b)

m'/m 界面の m' 側の分極からの SFG :

(a): 反射方向

ファイル「一般式」の (2.1) 式と (2.3) 式において、 $z_1 = h_m^-$ 、 $a_0^* = 1$ 、 $a_0 = a$ とする。

$$E_{1,0}^-(0^-)_{net} = \frac{at_{m1} [(r_{m'm} + r_{m2} b^2) L_{m'/m'}^+ + (1 + r_{mm'} r_{m2} b^2) L_{m'/m'}^-]}{1 + r_{1m'} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} P^* (z_1 = h_m^-)$$

ここで、

$$t_{m1,p} L_{m'/m',px}^+ = t_{m1,p} L_{m'/m',px}^- = L_{1/m',px}^-$$

$$t_{m1,s} L_{m'/m',sy}^+ = t_{m1,s} L_{m'/m',sy}^- = L_{1/m',sy}^-$$

$$t_{m1,p} L_{m'/m',pz}^+ = t_{m1,p} L_{m'/m',pz}^- = -L_{1/m',pz}^- \quad (n_m^+ = n_m^-)$$

であるから、

$$E_{-1}^{-1}(0^-)_{net} = \frac{a[(1+r_{mm'}r_{m2}b^2) \pm (r_{m'm} + r_{m2}b^2)]L_{-1/m'}^-}{1+r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2} P^* (z_1 = h_{m'})$$

$$= \frac{a(1 \pm r_{mm'})(1 \pm r_{m2}b^2)L_{-1/m'}^-}{1+r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2} P^* (z_1 = h_{m'})$$

(upper sign for x and y components, lower sign for z component)

(2.23) 式を参照して、

$$E_{-1p}^{-1}(0^-)_{net} = \sum_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m':vis} h_{m'}} (1+r_{m'm,vis\alpha})(1+r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_{m'}})}{1+r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m':vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m':vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}$$

$$\times \frac{t_{1m',jr\beta} e^{i\beta_{m':jr} h_{m'}} (1+r_{m'm,jr\beta})(1+r_{m2,jr\beta} e^{2i\beta_{m',jr} h_{m'}})}{1+r_{1m',jr\beta} r_{m'm,jr\beta} e^{2i\beta_{m':jr} h_{m'}} + (r_{m'm,jr\beta} + r_{1m',jr\beta} e^{2i\beta_{m':jr} h_{m'}}) r_{m2,jr\beta} e^{2i\beta_{m',jr} h_{m'}}$$

$$\times \left\{ \frac{e^{i\beta_{m':SFp} h_{m'}} [(1+r_{mm',SFp})(1+r_{m2,SFp} e^{2i\beta_{m',SFp} h_{m'}}) L_{-1/m',px}^- \chi_{\alpha\beta}]}{1+r_{1m',SFp} r_{m'm,SFp} e^{2i\beta_{m':SFp} h_{m'}} + (r_{m'm,SFp} + r_{1m',SFp} e^{2i\beta_{m':SFp} h_{m'}}) r_{m2,SFp} e^{2i\beta_{m',SFp} h_{m'}}} \right.$$

$$\left. + \frac{e^{i\beta_{m':SFp} h_{m'}} [(1-r_{mm',SFp})(1-r_{m2,SFp} e^{2i\beta_{m',SFp} h_{m'}}) L_{-1/m',pz}^- \chi_{\alpha\beta}]}{1+r_{1m',SFp} r_{m'm,SFp} e^{2i\beta_{m':SFp} h_{m'}} + (r_{m'm,SFp} + r_{1m',SFp} e^{2i\beta_{m':SFp} h_{m'}}) r_{m2,SFp} e^{2i\beta_{m',SFp} h_{m'}}} \right\} \quad (n_{m''} = n_{m'}) \quad (2.39a)$$

$$E_{-1s}^{-1}(0^-)_{net} = \sum_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m':vis} h_{m'}} (1+r_{m'm,vis\alpha})(1+r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_{m'}})}{1+r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m':vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m':vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}$$

$$\times \frac{t_{1m',jr\beta} e^{i\beta_{m':jr} h_{m'}} (1+r_{m'm,jr\beta})(1+r_{m2,jr\beta} e^{2i\beta_{m',jr} h_{m'}})}{1+r_{1m',jr\beta} r_{m'm,jr\beta} e^{2i\beta_{m':jr} h_{m'}} + (r_{m'm,jr\beta} + r_{1m',jr\beta} e^{2i\beta_{m':jr} h_{m'}}) r_{m2,jr\beta} e^{2i\beta_{m',jr} h_{m'}}$$

$$\times \frac{e^{i\beta_{m':SFs} h_{m'}} (1+r_{mm',SFs})(1+r_{m2,SFs} e^{2i\beta_{m',SFs} h_{m'}}) L_{-1/m',sy}^- \chi_{\alpha\beta}}{1+r_{1m',SFs} r_{m'm,SFs} e^{2i\beta_{m':SFs} h_{m'}} + (r_{m'm,SFs} + r_{1m',SFs} e^{2i\beta_{m':SFs} h_{m'}}) r_{m2,SFs} e^{2i\beta_{m',SFs} h_{m'}}} \quad (2.39b)$$

(b): 透過方向

ファイル「一般式」の (2.2) 式と (2.4) 式において、 $z_1 = h_{m'}$ 、 $a_0^* = 1$ 、 $a_0 = a$ とする。

$$E_{+2}^+(h_{m'} + h_{m'}^+)_{net} = \frac{t_{m2} t_{m'm} b (L_{m'/m'}^+ + r_{m1} a^2 L_{-m'/m'}^-)}{1+r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2} P^* (z_1 = h_{m'})$$

ここで、

$$t_{m'm,p} L_{m'/m',px}^+ = t_{m'm,p} L_{-m'/m',px}^- = L_{m'/m,px}^+$$

$$t_{m'm,s} L_{m'/m',sy}^+ = t_{m'm,s} L_{-m'/m',sy}^- = L_{m'/m,sy}^+$$

$$t_{m'm,p} L^+_{m'/m,pz} = -t_{m'm,p} L^-_{m'/m,pz} = L^+_{m'/m,pz} \quad (n_{m''} = n_{m'})$$

であるから、

$$E^+_{2}(h_{m'} + h_{m''})_{net} = \frac{t_{m2} b (1 \pm r_{m1} a^2) L^+_{m'/m}}{1 + r_{1m} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} P^* (z_1 = h_{m'})$$

(upper sign for x and y components, lower sign for z component)

(2.23) 式を参照して、

$$E^+_{2,p}(h_{m'} + h_{m''})_{net} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m':vis} h_{m'}} (1 + r_{m'm,vis\alpha}) (1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m':vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir,\beta} e^{i\beta_{m':ir} h_{m'}} (1 + r_{m'm,ir,\beta}) (1 + r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m':ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \frac{t_{m2,SF,p} e^{i\beta_{m',SF,p} h_{m'}} [(1 + r_{m1,SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) L^+_{m'/m,px} \chi_{\alpha\beta} + (1 - r_{m1,SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) L^+_{m'/m,zx} \chi_{\alpha\beta}]}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF,p} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF,p} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF,p} h_m}} \quad (n_{m''} = n_{m'})$$

(2.40a)

$$E^+_{2,s}(h_{m'} + h_{m''})_{net} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} e^{i\beta_{m':vis} h_{m'}} (1 + r_{m'm,vis\alpha}) (1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m':vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir,\beta} e^{i\beta_{m':ir} h_{m'}} (1 + r_{m'm,ir,\beta}) (1 + r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m':ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \frac{t_{m2,SF,s} e^{i\beta_{m',SF,s} h_{m'}} (1 + r_{m1,SF,s} e^{2i\beta_{m',SF,s} h_{m'}}) L^+_{m'/m,sy} \chi_{\alpha\beta}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF,s} h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF,s} h_{m'}}) r_{m2,SF,s} e^{2i\beta_{m,SF,s} h_m}} \quad (2.40b)$$

m'/m 界面の m 側の分極からの SFG :

(a): 反射方向

ファイル「一般式」の (2.5) 式と (2.7) 式において、 $z_2 = 0$ 、 $b_0^* = b$ 、 $b_0 = 1$ とする。

$$E^-_1(0^-)_{net} = \frac{at_{m1} t_{m'm} (r_{m2} b^2 L^+_{m'/m} + L^-_{m'/m})}{1 + r_{1m} r_{m'm} a^2 + (r_{m'm} + r_{1m} a^2) r_{m2} b^2} P^* (z_1 = h_{m'})$$

ここで、

$$t_{mm',p} L^+_{m'/m,px} = t_{mm',p} L^-_{m'/m,px} = L^-_{m'/m,px},$$

$$t_{mm',s} L^+_{m'/m,sy} = t_{mm',s} L^-_{m'/m,sy} = L^-_{m'/m,sy},$$

$$t_{mm',p} L^+_{m'/m,pa} = -t_{mm',p} L^-_{m'/m,pa} = -L^-_{m'/m,pa} \quad (n_{m''} = n_m)$$

であるから、

$$E^{-1}(0^-)_{net} = \frac{at_{m1}(1 \pm r_{m2}b^2)L^-_{m/m}}{1 + r_{1m}r_{m1m}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^* (z_1 = h_m)$$

(upper sign for x and y components, lower sign for z component)

(2.25) 式を参照して、

$$E^{-1p}(0^-)_{net} = \sum_{\alpha, \beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{\beta_{m'vis} h_m} (1 + r_{m2vis\alpha} e^{2\beta_{m'vis} h_m})}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_m} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'vis} h_m}) r_{m2vis\alpha} e^{2\beta_{m'vis} h_m}}$$

$$\times \frac{t_{1m'jr,\beta} e^{\beta_{m'jr} h_m} (1 + r_{m2jr,\beta}) (1 + r_{m'mjr,\beta} e^{2i\beta_{m'jr} h_m})}{1 + r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m'jr} h_m} + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m'jr} h_m}) r_{m2jr,\beta} e^{2\beta_{m'jr} h_m}}$$

$$\times \frac{t_{m1SF,p} e^{i\beta_{m'SF} h_m} [(1 + r_{m2SF,p} e^{2i\beta_{m'SF} h_m}) L^-_{m'/m,px} \chi_{\alpha\beta} + (1 - r_{m2SF,p} e^{2\beta_{m'SF} h_m}) L^-_{m'/m,pz} \chi_{\alpha\beta}]}{1 + r_{1m'SF,p} r_{m'mSF,p} e^{2\beta_{m'SF} h_m} + (r_{m'mSF,p} + r_{1m'SF,p} e^{2i\beta_{m'SF} h_m}) r_{m2SF,p} e^{2\beta_{m'SF} h_m}} \quad (n_m'' = n_m)$$

(2.41a)

$$E^{-1s}(0^-)_{net} = \sum_{\alpha, \beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{\beta_{m'vis} h_m} (1 + r_{m2vis\alpha} e^{2\beta_{m'vis} h_m})}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_m} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'vis} h_m}) r_{m2vis\alpha} e^{2\beta_{m'vis} h_m}}$$

$$\times \frac{t_{1m'jr,\beta} e^{\beta_{m'jr} h_m} (1 + r_{m'mjr,\beta}) (1 + r_{m2jr,\beta} e^{2i\beta_{m'jr} h_m})}{1 + r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m'jr} h_m} + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m'jr} h_m}) r_{m2jr,\beta} e^{2\beta_{m'jr} h_m}}$$

$$\times \frac{t_{m1SF,s} e^{\beta_{m'SF} h_m} (1 + r_{m2SF,s} e^{2i\beta_{m'SF} h_m}) L^-_{m'/m,sy} \chi_{y\alpha\beta}}{1 + r_{1m'SF,s} r_{m'mSF,s} e^{2\beta_{m'SF} h_m} + (r_{m'mSF,s} + r_{1m'SF,s} e^{2i\beta_{m'SF} h_m}) r_{m2SF,s} e^{2\beta_{m'SF} h_m}} \quad (2.41b)$$

(b): 透過方向

ファイル「一般式」の (2.6) 式と (2.8) 式において、 $z_2 = 0$ 、 $b_0^* = b$ 、 $b_0 = 1$ とする。

$$E^{+2}(h_m^- + h_m^+)_{net} = \frac{t_{m2}b[(1 + r_{1m}r_{m1m}a^2)L^+_{m/m} - (r_{m1m} + r_{1m}a^2)L^-_{m/m}]}{1 + r_{1m}r_{m1m}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^* (z_2 = 0)$$

ここで、

$$t_{m2,p} L^+_{m/m,px} = t_{m2,p} L^-_{m/m,px} = L^+_{m/2,px},$$

$$t_{m2,s} L^+_{m/m,sy} = t_{m2,s} L^-_{m/m,sy} = L^+_{m/2,sy},$$

$$t_{m2,p} L^+_{m/m,pz} = -t_{m2,p} L^-_{m/m,pz} = L^+_{m/2,pz} \quad (n_m'' = n_m)$$

であるから、

$$E^{+2}(h_m^- + h_m^+)_{net} = \frac{b[(1 + r_{1m}r_{m1m}a^2)m(r_{m'm} + r_{1m}a^2)]L^+_{m/2}}{1 + r_{1m}r_{m1m}a^2 + (r_{m'm} + r_{1m}a^2)r_{m2}b^2} P^* (z_2 = 0)$$

$$= \frac{b(1 - r_{m'm})(1 - r_{1m'}a^2)L^{+}_{m/2}}{1 + r_{1m'}r_{m'm}a^2 + (r_{m'm} + r_{1m'}a^2)r_{m2}b^2} P^* (z_2 = 0)$$

(upper sign for x and y components, lower sign for z component)

(2.25) 式を参照して、

$$E^{+}_{2,p}(h_{m'} + h_{m^+})_{net} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{\beta_{m',vis} h_{m'}} (1 + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir,\beta} e^{\beta_{m',ir} h_{m'}} (1 + r_{m'm,ir,\beta}) (1 + r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \left\{ \frac{e^{i\beta_{m,SF} h_m} (1 - r_{m'm,SF,p}) (1 - r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) L^{+}_{m/2} \chi_{\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2\beta_{m',SF} h_{m'}}) r_{m2,SF,p} e^{2\beta_{m,SF} h_m}} \right.$$

$$\left. + \frac{e^{i\beta_{m,SF} h_m} (1 + r_{m'm,SF,p}) (1 + r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) L^{+}_{m/2} \chi_{\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2\beta_{m',SF} h_{m'}}) r_{m2,SF,p} e^{2\beta_{m,SF} h_m}} \right\} \quad (n_{m''} = n_m) \quad (2.42a)$$

$$E^{+}_{2,s}(h_{m'} + h_{m^+})_{net} = \sum_{\alpha,\beta} E^0_{vis\alpha} E^0_{ir,\beta}$$

$$\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{\beta_{m',vis} h_{m'}} (1 + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m}}$$

$$\times \frac{t_{1m',ir,\beta} e^{\beta_{m',ir} h_{m'}} (1 + r_{m'm,ir,\beta}) (1 + r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m})}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}}$$

$$\times \frac{e^{\beta_{m,SF} h_m} (1 - r_{m'm,SF,s}) (1 - r_{1m',SF,s} e^{2\beta_{m',SF} h_{m'}}) L^{+}_{m/2} \chi_{\alpha\beta}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2\beta_{m',SF} h_{m'}}) r_{m2,SF,s} e^{2\beta_{m,SF} h_m}} \quad (2.42b)$$

m' 層の分極からの SFG :

ファイル「一般式」の(2.1)式 ~ (2.4)式において、下の定義を使う。

$$a_0 = e^{ik_m z_1 / \cos\theta_{m'}}, \quad a_0^* = e^{\beta_{m'} h_m / \cos\theta_{m'}} e^{-ik_m z_1 / \cos\theta_{m'}}$$

しかし、本稿の(2.10)式 ~ (2.17)式ひいては(2.27)式 ~ (2.30)式を導くために使う光路は、一つの層の内部での多重反射を考慮していない。すなわち、位相部分の扱いには不備がある。その不備は、指数関数の引数で $h/\cos\theta$ および $z/\cos\theta$ の形になっている部分を $\beta \times h$ および $\beta \times z$ と置き換えることで修正できるので、その置き換えを行った結果を以下では記す。手始めに、以下では $a_0 = e^{i\beta_{m'} z_1}$ 、 $a_0^* = e^{\beta_{m'} h_m} e^{-i\beta_{m'} z_1}$ とする。また、上で行ったと同様に下のように置く。

$$\begin{aligned}
P_a^* &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{t_{1m'vis\alpha}}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m':vis} h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m':vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m}} \\
&\times \frac{t_{1m'jr\beta}}{1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m':ir} h_{m'}} + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m':ir} h_{m'}}) r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}}
\end{aligned}$$

(a): 反射方向

E^+ sources からの寄与は、ファイル「一般式」の (2.1) 式と本稿の (2.27) 式により、下で表される。

$$\begin{aligned}
E^-_1(0^-) &= \sum_{\alpha\beta} t_{m1} e^{2i\beta_m h_{m'}} (r_{m'm} + r_{m2} e^{2i\beta_m h_m}) L^+_{m'/m} P_a^* \\
&\times \{(1 + r_{m'mvis\alpha} r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(1 + r_{m'mjr\beta} r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) \exp[iz_1(-\beta_{m'SF} + \beta_{m'vis} + \beta_{m'jr})] \\
&+ (1 + r_{m'mvis\alpha} r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(r_{m'mjr\beta} + r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) e^{2i\beta_{m':ir} h_{m'}} \exp[iz_1(-\beta_{m'SF} + \beta_{m'vis} - \beta_{m'jr})] \\
&+ (r_{m'mvis\alpha} + r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(1 + r_{m'mjr\beta} r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) e^{2i\beta_{m':vis} h_{m'}} \exp[iz_1(-\beta_{m'SF} - \beta_{m'vis} + \beta_{m'jr})] \\
&+ (r_{m'mvis\alpha} + r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(r_{m'mjr\beta} + r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) e^{2i(\beta_{m':vis} + \beta_{m':ir}) h_{m'}} \exp[iz_1(-\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr})]\}
\end{aligned}$$

E^- sources からの寄与は、ファイル「一般式」の(2.3)式と本稿の (2.28) 式により下で表される。

$$\begin{aligned}
E^-_1(0^-) &= \sum_{\alpha\beta} t_{m1} (1 + r_{mm'} r_{m2} e^{2i\beta_m h_m}) L^-_{m'/m} P_a^* \\
&\times \{(1 + r_{m'mvis\alpha} r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(1 + r_{m'mjr\beta} r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) \exp[iz_1(\beta_{m'SF} + \beta_{m'vis} + \beta_{m'jr})] \\
&+ (1 + r_{m'mvis\alpha} r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(r_{m'mjr\beta} + r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) e^{2i\beta_{m':ir} h_{m'}} \exp[iz_1(\beta_{m'SF} + \beta_{m'vis} - \beta_{m'jr})] \\
&+ (r_{m'mvis\alpha} + r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(1 + r_{m'mjr\beta} r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) e^{2i\beta_{m':vis} h_{m'}} \exp[iz_1(\beta_{m'SF} - \beta_{m'vis} + \beta_{m'jr})] \\
&+ (r_{m'mvis\alpha} + r_{m2vis\alpha} e^{2i\beta_{m:vis} h_m})(r_{m'mjr\beta} + r_{m2jr\beta} e^{2i\beta_{m:ir} h_m}) e^{2i(\beta_{m':vis} + \beta_{m':ir}) h_{m'}} \exp[iz_1(\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr})]\}
\end{aligned}$$

ここで、 E^+ に由来する SFG 光については z_1 について 0 から $h_{m'}$ まで ($z_1 = 0 \rightarrow h_{m'}$)、 E^- に由来する SFG 光については z_1 について $h_{m'}$ から 0 まで ($z_1 = h_{m'} \rightarrow 0$) 積分し、さらに関係式

$$\begin{aligned}
t_{m'1p} L^+_{m'/m',px} &= L^-_{1/m',px}, & t_{m'1s} L^+_{m'/m',sy} &= L^-_{1/m',sy}, & t_{m'1p} L^+_{m'/m',pz} &= -L^-_{1/m',pz} & (n_m'' = n_m) \\
t_{m'1p} L^-_{m'/m',px} &= L^-_{1/m',px}, & t_{m'1s} L^-_{m'/m',sy} &= L^-_{1/m',sy}, & t_{m'1p} L^-_{m'/m',pz} &= L^-_{1/m',pz} & (n_m'' = n_m)
\end{aligned}$$

を考慮して整理すると、下式が得られる。

$$\begin{aligned}
E^{-1}(0^-)_{net} &= \sum_{\alpha\beta} L_{1/m}^- P_a^* \frac{i}{\delta} \\
&\times \{ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) \\
&\times [(1 + r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}} \\
&\quad \pm (r_{m'm,SF} + r_{m2,SF} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}} \frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}}] \\
&+ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m}) (r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',ir} h_{m'}} \\
&\times [(1 + r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}} \\
&\quad \pm (r_{m'm,SF} + r_{m2,SF} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}} \frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}}] \\
&+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m',vis} h_{m'}} \\
&\times [(1 + r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}} \\
&\quad \pm (r_{m'm,SF} + r_{m2,SF} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}} \frac{e^{i(-\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}}] \\
&+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m}) (r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir}) h_{m'}} \\
&\times [(1 + r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}} \\
&\quad \pm (r_{m'm,SF} + r_{m2,SF} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}} \frac{e^{i(-\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}}] \\
\end{aligned}$$

(upper sign for x and y components, lower sign for z component)

よって、

$$\begin{aligned}
E^{-1}(0^-)_p &= \sum_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \frac{i}{\delta} \\
&\times \frac{t_{1m,vis\alpha}}{1 + r_{1m,vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m}} \\
&\times \frac{t_{1m,ir\beta}}{1 + r_{1m,ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}} + (r_{m'm,ir\beta} + r_{1m,ir\beta} e^{2i\beta_{m',ir} h_{m'}}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}} \\
&\times \{ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) \\
&\times [(1 + r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}} \\
&\quad + (r_{m'm,SF,p} + r_{m2,SF,p} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m',SF} h_{m'}} \frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}) h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}}] \\
\end{aligned}$$

$$\begin{aligned}
& +(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})(r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m,ir} h_m} \\
& \times [(1 + r_{mm'SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}} - 1 \\
& + (r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) e^{2\beta_{m'SF} h_m} \frac{e^{i(-\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}}] \\
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})(1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m,ir} h_m} \\
& \times [(1 + r_{mm'SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}} - 1 \\
& + (r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) e^{2\beta_{m'SF} h_m} \frac{e^{i(-\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}}] \\
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})(r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir}) h_m} \\
& \times [(1 + r_{mm'SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m',vis} - \beta_{m',ir}} - 1 \\
& + (r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) e^{2\beta_{m'SF} h_m} \frac{e^{i(-\beta_{m'SF} - \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m',vis} + \beta_{m',ir}}] \} L^{-1/m,pz} \chi_{,\alpha\beta} \\
& + \{(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m})(1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2\beta_{m,ir} h_m}) \\
& + [(1 + r_{mm'SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m'SF} + \beta_{m',vis} + \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m',vis} + \beta_{m',ir}} - 1 \\
& - (r_{m'm,SF,p} + r_{m2,SF,p} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m'SF} h_m} \frac{e^{i(-\beta_{m'SF} + \beta_{m',vis} + \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m',vis} - \beta_{m',ir}}] \\
& + (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})(r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m,ir} h_m} \\
& + [(1 + r_{mm'SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}} - 1 \\
& - (r_{m'm,SF,p} + r_{m2,SF,p} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m'SF} h_m} \frac{e^{i(-\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}}] \\
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})(1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m,ir} h_m} \\
& + [(1 + r_{mm'SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}} - 1 \\
& - (r_{m'm,SF,p} + r_{m2,SF,p} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m'SF} h_m} \frac{e^{i(-\beta_{m'SF} - \beta_{m',vis} + \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m',vis} - \beta_{m',ir}}] \\
& + (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m})(r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir}) h_m} \\
& + [(1 + r_{mm'SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m',vis} - \beta_{m',ir}} - 1 \\
& - (r_{m'm,SF,p} + r_{m2,SF,p} e^{2\beta_{m,SF} h_m}) e^{2i\beta_{m'SF} h_m} \frac{e^{i(-\beta_{m'SF} - \beta_{m',vis} - \beta_{m',ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m',vis} + \beta_{m',ir}}] \} L^{-1/m,pz} \chi_{,\alpha\beta} \} \quad (n_m = n_m) \quad (2.43a)
\end{aligned}$$

$$\begin{aligned}
E^-_1(0^-)_s &= \sum_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} \frac{i}{\delta} \\
&\times \frac{t_{1m'vis\alpha}}{1 + r_{1m'vis\alpha} r_{m'vis\alpha} e^{2i\beta_{m';vis} h_{m'}} + (r_{m'vis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m';vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m}} \\
&\times \frac{t_{1m'ir\beta}}{1 + r_{1m'ir\beta} r_{m'ir\beta} e^{2i\beta_{m';ir} h_{m'}} + (r_{m'ir\beta} + r_{1m'ir\beta} e^{2i\beta_{m';ir} h_{m'}}) r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}} \\
&\times \{(1 + r_{m'vis\alpha} r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m})(1 + r_{m'ir\beta} r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}) \\
&\times [(1 + r_{mm'SF,s} r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) \frac{e^{i(\beta_{m';SF} + \beta_{m';vis} + \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} + \beta_{m';vis} + \beta_{m';ir}} \\
&\quad + (r_{m'SF,s} + r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) e^{2i\beta_{m';SF} h_m} \frac{e^{i(-\beta_{m';SF} + \beta_{m';vis} + \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} - \beta_{m';vis} - \beta_{m';ir}}] \\
&\quad + (1 + r_{m'vis\alpha} r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m})(r_{m'ir\beta} + r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}) e^{2i\beta_{m';ir} h_m} \\
&\times [(1 + r_{mm'SF,s} r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) \frac{e^{i(\beta_{m';SF} + \beta_{m';vis} - \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} + \beta_{m';vis} - \beta_{m';ir}} \\
&\quad + (r_{m'SF,s} + r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) e^{2i\beta_{m';SF} h_m} \frac{e^{i(-\beta_{m';SF} + \beta_{m';vis} - \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} - \beta_{m';vis} + \beta_{m';ir}}] \\
&\quad + (r_{m'vis\alpha} + r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m})(1 + r_{m'ir\beta} r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}) e^{2i\beta_{m';ir} h_m} \\
&\times [(1 + r_{mm'SF,s} r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) \frac{e^{i(\beta_{m';SF} - \beta_{m';vis} + \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} - \beta_{m';vis} + \beta_{m';ir}} \\
&\quad + (r_{m'SF,s} + r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) e^{2i\beta_{m';SF} h_m} \frac{e^{i(-\beta_{m';SF} - \beta_{m';vis} + \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} + \beta_{m';vis} - \beta_{m';ir}}] \\
&\quad + (r_{m'vis\alpha} + r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m})(r_{m'ir\beta} + r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}) e^{2i(\beta_{m';vis} + \beta_{m';ir}) h_m} \\
&\times [(1 + r_{mm'SF,s} r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) \frac{e^{i(\beta_{m';SF} - \beta_{m';vis} - \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} - \beta_{m';vis} - \beta_{m';ir}} \\
&\quad + (r_{m'SF,s} + r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) e^{2i\beta_{m';SF} h_m} \frac{e^{i(-\beta_{m';SF} - \beta_{m';vis} - \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} + \beta_{m';vis} + \beta_{m';ir}}] \\
&\quad + (r_{m'vis\alpha} + r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m})(r_{m'ir\beta} + r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}) e^{2i(\beta_{m';vis} + \beta_{m';ir}) h_m} \\
&\times [(1 + r_{mm'SF,s} r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) \frac{e^{i(\beta_{m';SF} - \beta_{m';vis} - \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} - \beta_{m';vis} - \beta_{m';ir}} \\
&\quad + (r_{m'SF,s} + r_{m2SF,s} e^{2i\beta_{m';SF} h_m}) e^{2i\beta_{m';SF} h_m} \frac{e^{i(-\beta_{m';SF} - \beta_{m';vis} - \beta_{m';ir}) h_{m'}} - 1}{\beta_{m';SF} + \beta_{m';vis} + \beta_{m';ir}}] \} L^-_{1/m'sy} \chi_{y\alpha\beta} \tag{2.43b}
\end{aligned}$$

(b): 透過方向

E^+ sources からの寄与は、ファイル「一般式」の (2.2) 式と本稿の (2.27) 式により、下で表される。

$$\begin{aligned}
E^+_2(h_{m'} + h_m^+) &= \sum_{\alpha\beta} t_{m2} e^{i\beta_{m'} h_{m'}} t_{m'm} L^+_{m'/m} P_a^* \\
&\times \{(1 + r_{m'vis\alpha} r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m})(1 + r_{m'ir\beta} r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}) \exp[iz_1(-\beta_{m'SF} + \beta_{m';vis} + \beta_{m';ir})] \\
&\quad + (1 + r_{m'vis\alpha} r_{m2vis\alpha} e^{2i\beta_{m';vis} h_m})(r_{m'ir\beta} + r_{m2ir\beta} e^{2i\beta_{m';ir} h_m}) e^{2i\beta_{m';ir} h_m} \exp[iz_1(-\beta_{m'SF} + \beta_{m';vis} - \beta_{m';ir})]
\end{aligned}$$

$$\begin{aligned}
&+(r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(1 + r_{m'ir,\beta} r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',vis}h_m} \exp[iz_1(-\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})] \\
&+(r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'ir,\beta} + r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_m} \exp[iz_1(-\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir})]
\end{aligned}$$

E sources からの寄与は、ファイル「一般式」の (2.4) 式と本稿の (2.28) 式により、下で表される。

$$\begin{aligned}
E^+_2(h_m^+ + h_m^-) &= \sum_{\alpha\beta} t_{m2} e^{i\beta_{m'}h_m} r_{m1} t_{m'm} L_{m'/m}^+ P_a^* \\
&\times \{(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(1 + r_{m'ir,\beta} r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) \exp[iz_1(\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir})] \\
&+(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'ir,\beta} + r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',ir}h_m} \exp[iz_1(\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir})] \\
&+(r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(1 + r_{m'ir,\beta} r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',vis}h_m} \exp[iz_1(\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})] \\
&+(r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'ir,\beta} + r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_m} \exp[iz_1(\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir})]\}
\end{aligned}$$

ここで、 E^+ に由来する SFG 光については z_1 について 0 から $h_{m'}$ まで ($z_1 = 0 \rightarrow h_{m'}$)、 E^- に由来する SFG 光については z_1 について $h_{m'}$ から 0 まで ($z_1 = h_{m'} \rightarrow 0$) 積分し、さらに関係式

$$\begin{aligned}
t_{m'm,p} L_{m'/m}^+ &= L_{m'/m,px}^+, & t_{m'm,s} L_{m'/m}^+ &= L_{m'/m,sy}^+, & t_{m'm,p} L_{m'/m}^+ &= L_{m'/m,pz}^+ & (n_m^- = n_m) \\
t_{m'm,p} L_{m'/m}^- &= L_{m'/m,px}^-, & t_{m'm,s} L_{m'/m}^- &= L_{m'/m,sy}^-, & t_{m'm,p} L_{m'/m}^- &= -L_{m'/m,pz}^+ & (n_m^- = n_m)
\end{aligned}$$

を考慮して整理すると、下式が得られる。

$$\begin{aligned}
E^+_2(h_m^+ + h_m^-) &= \sum_{\alpha\beta} t_{m2} e^{i(\beta_{m'}h_m + \beta_{m'}h_m)} L_{m'/m}^+ P_a^* \frac{i}{\delta} \\
&\times \{(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(1 + r_{m'ir,\beta} r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) \\
&\times \left[\frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir})h_m} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}} \pm r_{m1} \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir})h_m} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}} \right] \\
&+(1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'ir,\beta} + r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',ir}h_m} \\
&\times \left[\frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir})h_m} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}} \pm r_{m1} \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir})h_m} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}} \right] \\
&+(r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(1 + r_{m'ir,\beta} r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',vis}h_m} \\
&\times \left[\frac{e^{i(-\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})h_m} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}} \pm r_{m1} \frac{e^{i(\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})h_m} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}} \right] \\
&+(r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2\beta_{m,vis}h_m})(r_{m'ir,\beta} + r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_m}
\end{aligned}$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}} \pm r_{m1} \frac{e^{i(\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}} \right]$$

(upper sign for x and y components, lower sign for z component)

よって、

$$E^{+2p}(h_{m'} + h_m^+) = \sum_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} t_{m2} e^{i(\beta_{m'}h_{m'} + \beta_{m'}h_m)} \frac{i}{\delta}$$

$$\times \frac{t_{1m',vis\alpha}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}}$$

$$\times \frac{t_{1m',ir\beta}}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir}h_{m'}}) r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}}$$

$$\times \{ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m})$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}} + r_{m1,SF,p} \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}} \right]$$

$$+ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',ir}h_{m'}}$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}} + r_{m1,SF,p} \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}} \right]$$

$$+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_{m'}}$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}} + r_{m1,SF,p} \frac{e^{i(\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}} \right]$$

$$+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_{m'}}$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}} + r_{m1,SF,p} \frac{e^{i(\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}} \right] \} L^{+m'/m,px} \chi_{x\alpha\beta}$$

$$+ \{ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m})$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} - \beta_{m',ir}} - r_{m1,SF,p} \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} + \beta_{m',ir}} \right]$$

$$+ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',ir}h_{m'}}$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}} - r_{m1,SF,p} \frac{e^{i(\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}} \right]$$

$$+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (1 + r_{m'm,ir\beta} r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}) e^{2i\beta_{m',vis}h_{m'}}$$

$$\times \left[\frac{e^{i(-\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} + \beta_{m',vis} - \beta_{m',ir}} - r_{m1,SF,p} \frac{e^{i(\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir})h_{m'}} - 1}{\beta_{m',SF} - \beta_{m',vis} + \beta_{m',ir}} \right]$$

$$+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_m}) (r_{m'm,ir\beta} + r_{m2,ir\beta} e^{2i\beta_{m,ir}h_m}) e^{2i(\beta_{m',vis} + \beta_{m',ir})h_{m'}}$$

$$\times \left[\frac{e^{i(-\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} + \beta_{m'vis} + \beta_{m'jr}} - r_{m1,SF,p} \frac{e^{i(\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr}} \right] L^{+m'/m, p, z} \chi_{\alpha\beta} \quad (n_{m'} = n_m) \quad (2.44a)$$

$$\begin{aligned} E_{2s}^+(h_m + h_m^+) &= \sum_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 t_{m2} e^{i(\beta_m h_m + \beta_m h_m^+)} \frac{i}{\delta} \\ &\times \frac{t_{1m'vis\alpha}}{1 + r_{1m'vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m':vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m':vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\ &\times \frac{t_{1m'jr\beta}}{1 + r_{1m'jr\beta} r_{m'm,jr\beta} e^{2i\beta_{m':jr} h_{m'}} + (r_{m'm,jr\beta} + r_{1m'jr\beta} e^{2i\beta_{m':jr} h_{m'}}) r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}} \\ &\times \{ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (1 + r_{m'm,jr\beta} r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) \\ &\times \left[\frac{e^{i(-\beta_{m'SF} + \beta_{m'vis} + \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr}} + r_{m1,SF,s} \frac{e^{i(\beta_{m'SF} + \beta_{m'vis} + \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} + \beta_{m'vis} + \beta_{m'jr}} \right] \\ &+ (1 + r_{m'm,vis\alpha} r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (r_{m'm,jr\beta} + r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m,ir} h_m} \\ &\times \left[\frac{e^{i(-\beta_{m'SF} + \beta_{m'vis} - \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} - \beta_{m'vis} + \beta_{m'jr}} + r_{m1,SF,s} \frac{e^{i(\beta_{m'SF} + \beta_{m'vis} - \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} + \beta_{m'vis} - \beta_{m'jr}} \right] \\ &+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (1 + r_{m'm,jr\beta} r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) e^{2i\beta_{m,vis} h_m} \\ &\times \left[\frac{e^{i(-\beta_{m'SF} - \beta_{m'vis} + \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} + \beta_{m'vis} - \beta_{m'jr}} + r_{m1,SF,s} \frac{e^{i(\beta_{m'SF} - \beta_{m'vis} + \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} - \beta_{m'vis} + \beta_{m'jr}} \right] \\ &+ (r_{m'm,vis\alpha} + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}) (r_{m'm,jr\beta} + r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}) e^{2i(\beta_{m,vis} + \beta_{m,ir})h_m} \\ &\times \left[\frac{e^{i(-\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} + \beta_{m'vis} + \beta_{m'jr}} + r_{m1,SF,s} \frac{e^{i(\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr})h_{m'}} - 1}{\beta_{m'SF} - \beta_{m'vis} - \beta_{m'jr}} \right] \} L^{+m'/m, s, y} \chi_{\alpha\beta} \quad (2.44b) \end{aligned}$$

m 層の分極からの SFG :

ファイル「一般式」の (2.5) 式 ~ (2.8) 式において、下の定義を使う。

$$\begin{aligned} b_0 &= e^{ik_{mz_2}/\cos\theta_m}, \quad b_0^* = e^{i\beta_m h_m / \cos\theta_m} e^{-ik_{mz_2}/\cos\theta_m} \\ P_a^* &= \sum_{\alpha\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\ &\times \frac{t_{1m'vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m':vis} h_{m'}}}{1 + r_{1m'vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m':vis} h_{m'}} + (r_{m'm,vis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m':vis} h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\ &\times \frac{t_{1m'jr\beta} t_{m'm,jr\beta} e^{i\beta_{m':jr} h_{m'}}}{1 + r_{1m'jr\beta} r_{m'm,jr\beta} e^{2i\beta_{m':jr} h_{m'}} + (r_{m'm,jr\beta} + r_{1m'jr\beta} e^{2i\beta_{m':jr} h_{m'}}) r_{m2,jr\beta} e^{2i\beta_{m,ir} h_m}} \end{aligned}$$

とおく。

(a): 反射方向

E^+ sources からの寄与は、ファイル「一般式」の (2.5) 式と本稿の (2.29) 式により、下で表される。

$$\begin{aligned}
E^{-1}(0^-) &= \sum_{\alpha\beta} t_{m1} t_{mm} r_{m2} e^{i\beta_m h_m} e^{2\beta_m h_m} L^+_{m/m} P_a^* \\
&\times \{ \exp[iz_2(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,jr})] + r_{m2,jr,\beta} e^{2i\beta_{m,ir} h_m} \exp[iz_2(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,jr})] \\
&+ r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m} \exp[iz_2(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,jr})] \\
&+ r_{m2,vis\alpha} r_{m2,jr,\beta} e^{2i(\beta_{m,jr} + \beta_{m,vis}) h_m} \exp[iz_2(-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,jr})] \}
\end{aligned}$$

E^- sources からの寄与は、ファイル「一般式」の (2.7) 式と本稿の (2.30) 式により、下で表される。

$$\begin{aligned}
E^{-1}(0^-) &= \sum_{\alpha\beta} t_{m1} t_{mm} e^{\beta_m h_m} L^-_{m/m} P_a^* \\
&\times \{ \exp[iz_2(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,jr})] + r_{m2,jr,\beta} e^{2i\beta_{m,ir} h_m} \exp[iz_2(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,jr})] \\
&+ r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m} \exp[iz_2(\beta_{m,SF} - \beta_{m,vis} + \beta_{m,jr})] \\
&+ r_{m2,vis\alpha} r_{m2,jr,\beta} e^{2i(\beta_{m,jr} + \beta_{m,vis}) h_m} \exp[iz_2(\beta_{m,SF} - \beta_{m,vis} - \beta_{m,jr})] \}
\end{aligned}$$

ここで、 E^+ に由来する SFG 光については z_2 について 0 から h_m まで ($z_2 = 0 \rightarrow h_m$)、 E^- に由来する SFG 光については z_2 について h_m から 0 まで ($z_2 = h_m \rightarrow 0$) 積分し、さらに関係式

$$\begin{aligned}
t_{mni,p} L^+_{m/m,px} &= L^-_{m/m,px}, & t_{mni,s} L^+_{m/m,sy} &= L^-_{m/m,sy}, & t_{mni,p} L^+_{m/m,pz} &= -L^-_{m/m,pz} & (n_m^+ = n_m) \\
t_{mni,p} L^-_{m/m,px} &= L^-_{m/m,px}, & t_{mni,s} L^-_{m/m,sy} &= L^-_{m/m,sy}, & t_{mni,p} L^-_{m/m,pz} &= L^-_{m/m,pz} & (n_m^- = n_m)
\end{aligned}$$

を考慮して整理すると、下式を得る。

$$\begin{aligned}
E^{-1}(0^-) &= \sum_{\alpha\beta} t_{m1} e^{\beta_m h_m} L^-_{m/m} P_a^* \frac{i}{\delta} \\
&\times \left\{ \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,jr}} \pm r_{m2} e^{2\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,jr}} \right] \right. \\
&+ r_{m2,jr,\beta} e^{2i\beta_{m,ir} h_m} \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} \beta_{m,jr}} \pm r_{m2} e^{2\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,jr}} \right] \\
&+ r_{m2,vis\alpha} e^{2\beta_{m,vis} h_m} \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} + \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,jr}} \pm r_{m2} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} - \beta_{m,jr}} \right] \\
&+ r_{m2,vis\alpha} r_{m2,jr,\beta} e^{2i(\beta_{m,vis} + \beta_{m,jr}) h_m} \left. \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} - \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,jr}} \pm r_{m2} e^{2\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,jr}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,jr}} \right] \right\} \\
&\text{(upper sign for x and y components, lower sign for z component)}
\end{aligned}$$

よって、

$$E^{-1}(0^-)_p = \sum_{\alpha\beta} E^0_{vis\alpha} E^0_{ir,\beta} t_{m1,SF,p} e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,jr}) h_m} \frac{i}{\delta}$$

$$\begin{aligned}
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha}}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m';vis} h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m';vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta}}{1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m';jr} h_{m'}} + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m';jr} h_{m'}}) r_{m2jr\beta} e^{2i\beta_{m,ir} h_m}} \\
& \times \left\{ \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}} + r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} \right] \right. \\
& + r_{m2jr\beta} e^{2i\beta_{m,ir} h_m} \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} \beta_{m,ir}} + r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} \right] \\
& \left. + r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m} \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} + r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}} \right] \right. \\
& + r_{m2vis\alpha} r_{m2jr\beta} e^{2i(\beta_{m,vis} + \beta_{m,ir}) h_m} \\
& \times \left. \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} + r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}} \right] \right\} L^{-m'/m,px} \chi_{\alpha\beta} \\
& \times \left\{ \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}} - r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} \right] \right. \\
& + r_{m2jr\beta} e^{2i\beta_{m,ir} h_m} \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} \beta_{m,ir}} - r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} \right] \\
& \left. + r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m} \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} - r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}} \right] \right. \\
& \left. + r_{m2vis\alpha} r_{m2jr\beta} e^{2i(\beta_{m,vis} + \beta_{m,ir}) h_m} \right. \\
& \times \left. \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} - r_{m2SF,p} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}} \right] \right\} L^{-m'/m,pz} \chi_{\alpha\beta} \quad (n_m = n_m)
\end{aligned} \tag{2.45a}$$

$$\begin{aligned}
E^{-1}(0^-)_s &= \sum_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} t_{m1SF,s} e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} \frac{i}{\delta} \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha}}{1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m';vis} h_{m'}} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m';vis} h_{m'}}) r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta}}{1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m';jr} h_{m'}} + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m';jr} h_{m'}}) r_{m2jr\beta} e^{2i\beta_{m,ir} h_m}} \\
& \times \left\{ \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}} + r_{m2SF,s} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} \right] \right. \\
& + r_{m2jr\beta} e^{2i\beta_{m,ir} h_m} \left[\frac{e^{i(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} \beta_{m,ir}} + r_{m2SF,s} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} \right] \\
& \left. + r_{m2vis\alpha} e^{2i\beta_{m,vis} h_m} \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} + r_{m2SF,s} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}} \right] \right. \\
& \left. + r_{m2vis\alpha} r_{m2jr\beta} e^{2i(\beta_{m,vis} + \beta_{m,ir}) h_m} \right. \\
& \times \left. \left[\frac{e^{i(\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} + r_{m2SF,s} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}} \right] \right\} L^{-m'/m,sy} \chi_{\alpha\beta}
\end{aligned} \tag{2.45b}$$

(b): 透過方向

E^+ sources からの寄与は、ファイル「一般式」の (2.6) 式と本稿の (2.29) 式により、下で表される。

$$\begin{aligned}
 E^+_{z_2}(h_m^+ + h_m^-) &= \sum_{\alpha\beta} t_{m2} e^{i\beta_m h_m} (1 + r_{1m} r_{m'm} e^{2i\beta_m h_m}) L^+_{m/m} P_a^* \\
 &\times \{ \exp[i z_2 (-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir})] + r_{m2,ir} \beta e^{2i\beta_{m,ir} h_m} \exp[i z_2 (-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir})] \\
 &+ r_{m2,vis} \alpha e^{2i\beta_{m,vis} h_m} \exp[i z_2 (-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir})] \\
 &+ r_{m2,vis} \alpha r_{m2,ir} \beta e^{2i(\beta_{m,ir} + \beta_{m,vis}) h_m} \exp[i z_2 (-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir})] \}
 \end{aligned}$$

E^- sources からの寄与は、ファイル「一般式」の (2.8) 式と本稿の (2.30) 式により、下で表される。

$$\begin{aligned}
 E^-_{z_2}(h_m^+ + h_m^-) &= -\sum_{\alpha\beta} t_{m2} e^{i\beta_m h_m} (r_{m'm} + r_{1m} e^{2i\beta_m h_m}) L^-_{m/m} P_a^* \\
 &\times \{ \exp[i z_2 (\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir})] + r_{m2,ir} \beta e^{2i\beta_{m,ir} h_m} \exp[i z_2 (\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir})] \\
 &+ r_{m2,vis} \alpha e^{2i\beta_{m,vis} h_m} \exp[i z_2 (\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir})] \\
 &+ r_{m2,vis} \alpha r_{m2,ir} \beta e^{2i(\beta_{m,ir} + \beta_{m,vis}) h_m} \exp[i z_2 (\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir})] \}
 \end{aligned}$$

ここで、 E^+ に由来する SFG 光については z_2 について 0 から h_m まで ($z_2 = 0 \rightarrow h_m$)、 E^- に由来する SFG 光については z_2 について h_m から 0 まで ($z_2 = h_m \rightarrow 0$) 積分し、さらに関係式

$$\begin{aligned}
 t_{m2p} L^+_{m/m,px} &= L^+_{m/2',px}, & t_{m2s} L^+_{m/m,sy} &= L^+_{m/2',sy}, & t_{m2p} L^+_{m/m,pz} &= L^+_{m/2',pz} & (n_m'' = n_m) \\
 t_{m2p} L^-_{m/m,px} &= L^+_{m/2',px}, & t_{m2s} L^-_{m/m,sy} &= L^+_{m/2',sy}, & t_{m2p} L^-_{m/m,pz} &= -L^+_{m/2',pz} & (n_m'' = n_m)
 \end{aligned}$$

を考慮して整理すると、下式を得る。

$$\begin{aligned}
 E^+_{z_2}(h_m^+ + h_m^-) &= \sum_{\alpha\beta} e^{i\beta_m h_m} L^+_{m/2} P_a^* \frac{i}{\delta} \\
 &\times \{ [(1 + r_{1m',SF} r_{m'm,SF} e^{2i\beta_{m',SF} h_m'}) \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} \\
 &\quad m(r_{m'm,SF} + r_{1m',SF} e^{2i\beta_{m',SF} h_m'}) \frac{e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}}] \\
 &+ r_{m2,ir} \beta e^{2i\beta_{m,ir} h_m} [(1 + r_{1m',SF} r_{m'm,SF} e^{2i\beta_{m',SF} h_m'}) \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} \\
 &\quad m(r_{m'm,SF} + r_{1m',SF} e^{2i\beta_{m',SF} h_m'}) \frac{e^{i(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}}] \\
 &+ r_{m2,vis} \alpha e^{2i\beta_{m,vis} h_m} [(1 + r_{1m',SF} r_{m'm,SF} e^{2i\beta_{m',SF} h_m'}) \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}}
 \end{aligned}$$

$$\begin{aligned}
& m(r_{m'SF} + r_{1m'SF} e^{2\beta_{m'SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}} \\
& + r_{m2,vis\alpha} r_{m2,ir\beta} e^{2i(\beta_{m',is} + \beta_{m,ir}) h_m} [(1 + r_{1m'SF} r_{m'm,SF} e^{2\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}} \\
& m(r_{m'SF} + r_{1m'SF} e^{2\beta_{m'SF} h_m}) \frac{e^{i(\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}}] \}
\end{aligned}$$

(upper sign for x and y components, lower sign for z component)

よって、

$$\begin{aligned}
E_{2,p}^+(h_m^+ + h_m^-) &= \sum_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 e^{i(\beta_{m',vis} + \beta_{m',ir}) h_m} e^{i\beta_{m,SF} h_m} (1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \\
&\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha}}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_m} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_m}) r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}} \\
&\times \frac{t_{1m',ir\beta} t_{m'm,ir\beta}}{1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_m} + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_m}) r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m}} \\
&\times \{ \{ [(1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}} \\
&\quad + (r_{m'm,SF,p} + r_{1m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}}] \\
&\quad + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m} [(1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}} \\
&\quad + (r_{m'm,SF,p} + r_{1m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}}] \\
&\quad + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m} [(1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}} \\
&\quad + (r_{m'm,SF,p} + r_{1m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}}] \\
&\quad + r_{m2,vis\alpha} r_{m2,ir\beta} e^{2i(\beta_{m',is} + \beta_{m,ir}) h_m} [(1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}} \\
&\quad + (r_{m'm,SF,p} + r_{1m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}}] \} \} L_{m/2,px}^+ \chi_{\alpha\beta} \\
&+ \{ [(1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}} \\
&\quad - (r_{m'm,SF,p} + r_{1m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}}] \\
&\quad + r_{m2,ir\beta} e^{2i\beta_{m,ir} h_m} [(1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}} \\
&\quad - (r_{m'm,SF,p} + r_{1m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}}] \\
&\quad + r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m} [(1 + r_{1m'SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}} \\
&\quad - (r_{m'm,SF,p} + r_{1m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}}] \} \} L_{m/2,py}^+ \chi_{\alpha\beta}
\end{aligned}$$

$$\begin{aligned}
& -(r_{m'SF,p} + r_{1m'SF,p} e^{2\beta_{m'SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}} \\
& + r_{m'2,vis\alpha} r_{m'2,ir\beta} e^{2i(\beta_{m',is} + \beta_{m,ir}) h_m} [(1 + r_{1m'SF,p} r_{m'SF,p} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}} \\
& -(r_{m'SF,p} + r_{1m'SF,p} e^{2\beta_{m'SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}}] \} L_{m/2,pz}^+ \chi_{\alpha\beta} \} \quad (n_{m'} = n_m) \quad (2.46a)
\end{aligned}$$

$$\begin{aligned}
E_{2s}^+(h_m^- + h_m^+) &= \sum_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 e^{i(\beta_{m',is} + \beta_{m,ir}) h_m} e^{\beta_{m'SF} h_m} (1 + r_{1m'SF,s} r_{m'SF,s} e^{2i\beta_{m',SF} h_m}) \\
& \times \frac{t_{1m',vis\alpha} t_{m',vis\alpha}}{1 + r_{1m',vis\alpha} r_{m',vis\alpha} e^{2i\beta_{m',is} h_m} + (r_{m',vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',is} h_m}) r_{m'2,vis\alpha} e^{2\beta_{m,vis} h_m}} \\
& \times \frac{t_{1m',ir\beta} t_{m',ir\beta}}{1 + r_{1m',ir\beta} r_{m',ir\beta} e^{2i\beta_{m',ir} h_m} + (r_{m',ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_m}) r_{m'2,ir\beta} e^{2i\beta_{m,ir} h_m}} \\
& \times \{ [(1 + r_{1m'SF,s} r_{m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}} \\
& + (r_{m'SF,s} + r_{1m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}}] \\
& + r_{m'2,ir\beta} e^{2i\beta_{m,ir} h_m} [(1 + r_{1m'SF,s} r_{m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}} \\
& + (r_{m'SF,s} + r_{1m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}}] \\
& + r_{m'2,vis\alpha} e^{2\beta_{m,vis} h_m} [(1 + r_{1m'SF,s} r_{m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} - \beta_{m,ir}} \\
& + (r_{m'SF,s} + r_{1m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} + \beta_{m,ir}}] \\
& + r_{m'2,vis\alpha} r_{m'2,ir\beta} e^{2i(\beta_{m',is} + \beta_{m,ir}) h_m} [(1 + r_{1m'SF,s} r_{m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(-\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} + \beta_{m,vis} + \beta_{m,ir}} \\
& + (r_{m'SF,s} + r_{1m'SF,s} e^{2i\beta_{m',SF} h_m}) \frac{e^{i(\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}) h_m} - 1}{\beta_{m'SF} - \beta_{m,vis} - \beta_{m,ir}}] \} L_{m/2,zy}^+ \chi_{\alpha\beta} \quad (2.46b)
\end{aligned}$$

3. 三層系 (1/m'/m/m''/2) からの SFG

始めに記したように、この系からの SFG 電場を求めるためにはテンソルの等比級数の和が必要になる。よって、最後の表式に至る作業は現在の私の力では不可能である。しかし、分極までは求めることが出来るので、それを記しておく。

但し、3つの層のうちのどれかがその厚みを無視できる場合には、2節で求めた結果に対して (1) 分極の表式を下で示すものと置き換え、(2) その層の外側界面が関係する反射係数と透過係数を下のように置き換えることによって、必要な表式が得られる。

2つの層 m/m' の間に厚みが無視できる m'' 層が挟まって m/m''/m' 系になっているときには、下の置き換えをする。

$$r_{mm'} \Rightarrow \frac{r_{mm''} + r_{m'm'}}{1 + r_{m'm''} r_{m''m}}, \quad t_{mm'} \Rightarrow \frac{t_{mm''} t_{m''m'}}{1 + r_{m'm''} r_{m''m}}$$

$$r_{m'm} \Rightarrow \frac{r_{m'm''} + r_{m''m}}{1 + r_{m'm''} r_{m''m}}, \quad t_{m'm} \Rightarrow \frac{t_{m'm''} t_{m''m}}{1 + r_{m'm''} r_{m''m}}$$

3.1. 電場振幅の積

1/m' 界面の 1 側 :

E^+ (by reflection and transmission) and E^- (for $n = 0$) sources

$$E_{vis\alpha}(0^-)E_{ir\beta}(0^-) = E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\begin{aligned} & \left\{ (1 + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \right. \\ & \left. + (r_{m'm,vis\alpha} + e^{2i\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m',vis} h_{m'}}] \right\} \\ & \times \frac{\left\{ (1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \right. \\ & \left. + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m',vis} h_{m'}} \right\}}{\left\{ (1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \right. \\ & \left. + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m',vis} h_{m'}} \right\}} \\ & \left\{ (1 + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m'}}) [(1 + r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \right. \\ & \left. + (r_{m'm,ir\beta} + e^{2i\beta_{m',ir} h_{m'}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) e^{2i\beta_{m',ir} h_{m'}}] \right\} \\ & \times \frac{\left\{ (1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \right. \\ & \left. + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) e^{2i\beta_{m',ir} h_{m'}} \right\}}{\left\{ (1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \right. \\ & \left. + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) e^{2i\beta_{m',ir} h_{m'}} \right\}} \\ & \times \exp[i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF}) (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (3.1)$$

1/m' 界面の m' 側 :

E^+ and E^- (by reflection and transmission) sources

$$E_{vis\alpha}(0^+)E_{ir\beta}(0^+) = E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\begin{aligned} & \left\{ t_{1m',vis\alpha} [(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \right. \\ & \left. + (r_{m'm,vis\alpha} + e^{2i\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m',vis} h_{m'}}] \right\} \\ & \times \frac{\left\{ (1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \right. \\ & \left. + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m',vis} h_{m'}} \right\}}{\left\{ (1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \right. \\ & \left. + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m',vis} h_{m'}} \right\}} \\ & \left\{ t_{1m',ir\beta} [(1 + r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \right. \\ & \left. + (r_{m'm,ir\beta} + e^{2i\beta_{m',ir} h_{m'}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) e^{2i\beta_{m',ir} h_{m'}}] \right\} \\ & \times \frac{\left\{ (1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \right. \\ & \left. + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) e^{2i\beta_{m',ir} h_{m'}} \right\}}{\left\{ (1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \right. \\ & \left. + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m'}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) e^{2i\beta_{m',ir} h_{m'}} \right\}} \\ & \times \exp[i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF}) (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (3.2)$$

m''/2 界面の 2 側 :

E^+ (by reflection and transmission) and E^- sources

$$E_{vis\alpha}(h_{m'} + h_m + h_{m''}^+) E_{ir\beta}(h_{m'} + h_m + h_{m''}^+) = E_{vis\alpha}^0 E_{ir\beta}^0$$

$$\begin{aligned}
& \times \frac{t_{1m'}\text{vis}\alpha t_{m'm}\text{vis}\alpha t_{mm''}\text{vis}\alpha t_{m''2}\text{vis}\alpha e^{i(\beta_{m'}\text{vis}h_{m'} + \beta_{m'}\text{vis}h_{m'} + \beta_{m''}\text{vis}h_{m''})}}{\{(1 + r_{1m'}\text{vis}\alpha r_{m'm}\text{vis}\alpha e^{2\beta_{m'}\text{vis}h_{m'}})(1 + r_{mm''}\text{vis}\alpha r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}})\}} \\
& + (r_{m'm}\text{vis}\alpha + r_{1m'}\text{vis}\alpha e^{2\beta_{m'}\text{vis}h_{m'}})(r_{mm''}\text{vis}\alpha + r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}})e^{2i\beta_{m'}\text{vis}h_{m'}} \} \\
& \times \frac{t_{1m'}\text{ir}\beta t_{m'm}\text{ir}\beta t_{mm''}\text{ir}\beta t_{m''2}\text{ir}\beta e^{i(\beta_{m'}\text{ir}h_{m'} + \beta_{m'}\text{ir}h_{m'} + \beta_{m''}\text{ir}h_{m''})}}{\{(1 + r_{1m'}\text{ir}\beta r_{m'm}\text{ir}\beta e^{2i\beta_{m'}\text{ir}h_{m'}})(1 + r_{mm''}\text{ir}\beta r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}})\}} \\
& + (r_{m'm}\text{ir}\beta + r_{1m'}\text{ir}\beta e^{2i\beta_{m'}\text{ir}h_{m'}})(r_{mm''}\text{ir}\beta + r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}})e^{2i\beta_{m'}\text{ir}h_{m'}} \} \\
& \times \exp[i(2n+1)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})]
\end{aligned} \tag{3.3}$$

m''/2 界面の m'' 側 :

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
& E_{\text{vis}\alpha}(h_{m'} + h_m + h_{m''}^-)E_{\text{ir}\beta}(h_{m'} + h_m + h_{m''}^-) = E^0_{\text{vis}\alpha}E^0_{\text{ir}\beta} \\
& \times \frac{t_{1m'}\text{vis}\alpha t_{m'm}\text{vis}\alpha t_{mm''}\text{vis}\alpha (1 + r_{m''2}\text{vis}\alpha) e^{i(\beta_{m'}\text{vis}h_{m'} + \beta_{m'}\text{vis}h_{m'} + \beta_{m''}\text{vis}h_{m''})}}{\{(1 + r_{1m'}\text{vis}\alpha r_{m'm}\text{vis}\alpha e^{2\beta_{m'}\text{vis}h_{m'}})(1 + r_{mm''}\text{vis}\alpha r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}})\}} \\
& + (r_{m'm}\text{vis}\alpha + r_{1m'}\text{vis}\alpha e^{2\beta_{m'}\text{vis}h_{m'}})(r_{mm''}\text{vis}\alpha + r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}})e^{2i\beta_{m'}\text{vis}h_{m'}} \} \\
& \times \frac{t_{1m'}\text{ir}\beta t_{m'm}\text{ir}\beta t_{mm''}\text{ir}\beta (1 + r_{m''2}\text{ir}\beta) e^{i(\beta_{m'}\text{ir}h_{m'} + \beta_{m'}\text{ir}h_{m'} + \beta_{m''}\text{ir}h_{m''})}}{\{(1 + r_{1m'}\text{ir}\beta r_{m'm}\text{ir}\beta e^{2i\beta_{m'}\text{ir}h_{m'}})(1 + r_{mm''}\text{ir}\beta r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}})\}} \\
& + (r_{m'm}\text{ir}\beta + r_{1m'}\text{ir}\beta e^{2i\beta_{m'}\text{ir}h_{m'}})(r_{mm''}\text{ir}\beta + r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}})e^{2i\beta_{m'}\text{ir}h_{m'}} \} \\
& \times \exp[i(2n+1)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})]
\end{aligned} \tag{3.4}$$

m'/m 界面の m' 側 :

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
& E_{\text{vis}\alpha}(h_{m'}^-)E_{\text{ir}\beta}(h_{m'}^-) = E^0_{\text{vis}\alpha}E^0_{\text{ir}\beta} \\
& \times \frac{\{t_{1m'}\text{vis}\alpha e^{\beta_{m'}\text{vis}h_{m'}}(1 + r_{m'm}\text{vis}\alpha)[(1 + r_{mm''}\text{vis}\alpha r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}}) \\
& + (r_{mm''}\text{vis}\alpha + r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}})e^{2i\beta_{m'}\text{vis}h_{m'}}]\}} \\
& \times \frac{\{t_{1m'}\text{ir}\beta e^{i\beta_{m'}\text{ir}h_{m'}}(1 + r_{m'm}\text{ir}\beta)[(1 + r_{mm''}\text{ir}\beta r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}}) \\
& + (r_{mm''}\text{ir}\beta + r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}})e^{2i\beta_{m'}\text{ir}h_{m'}}]\}} \\
& \times \frac{\{t_{1m'}\text{vis}\alpha e^{\beta_{m'}\text{vis}h_{m'}}(1 + r_{m'm}\text{vis}\alpha)[(1 + r_{mm''}\text{vis}\alpha r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}}) \\
& + (r_{mm''}\text{vis}\alpha + r_{m''2}\text{vis}\alpha e^{2\beta_{m''}\text{vis}h_{m''}})e^{2i\beta_{m'}\text{vis}h_{m'}}]\}} \\
& \times \frac{\{t_{1m'}\text{ir}\beta e^{i\beta_{m'}\text{ir}h_{m'}}(1 + r_{m'm}\text{ir}\beta)[(1 + r_{mm''}\text{ir}\beta r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}}) \\
& + (r_{mm''}\text{ir}\beta + r_{m''2}\text{ir}\beta e^{2i\beta_{m''}\text{ir}h_{m''}})e^{2i\beta_{m'}\text{ir}h_{m'}}]\}} \\
& \times \exp[i(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \\
& \times \exp[i(2n+1)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})]
\end{aligned}$$

(3.5)

 E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
E_{vis\alpha}(h_{m'}^-)E_{ir\beta}(h_{m'}^-) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{\{t_{1m'vis\alpha} e^{\beta_{m',vis} h_{m'}} (1 + r_{m'm,vis\alpha}) [(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2\beta_{m',vis} h_{m''}}) \\
&\quad + (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m,vis} h_m}]\}}{\{(1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2\beta_{m',vis} h_{m''}}) \\
&\quad + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2\beta_{m',vis} h_{m''}}) e^{2i\beta_{m,vis} h_m}\}} \\
&\times \frac{\{t_{1m'jr\beta} e^{i\beta_{m',ir} h_{m''}} (1 + r_{m'm,ir\beta}) [(1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \\
&\quad + (r_{m'm,ir\beta} + e^{2i\beta_{m',ir} h_{m''}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2\beta_{m',ir} h_{m''}}) e^{2i\beta_{m,ir} h_m}]\}}{\{(1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) \\
&\quad + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m''}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) e^{2i\beta_{m,ir} h_m}\}} \\
&\times \exp[ih_{m'} \tan\theta_{m'SF} (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \\
&\times \exp[i2n(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF}) (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \quad (3.6)
\end{aligned}$$

m'/m 界面の m 側 : **E^+ and E^- (by reflection and transmission) sources**

$$\begin{aligned}
E_{vis\alpha}(h_{m'}^+)E_{ir\beta}(h_{m'}^+) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{t_{1m'vis\alpha} t_{m'm,vis\alpha} e^{\beta_{m',vis} h_{m'}} [(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) + (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2\beta_{m,vis} h_m}]}{\{(1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \\
&\quad + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m,vis} h_m}\}} \\
&\times \frac{t_{1m'jr\beta} t_{m'm,ir\beta} e^{i\beta_{m',ir} h_{m''}} [(1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2\beta_{m',ir} h_{m''}}) + (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2\beta_{m',ir} h_{m''}}) e^{2i\beta_{m,ir} h_m}]}{\{(1 + r_{1m',ir\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir} h_{m''}}) (1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2\beta_{m',ir} h_{m''}}) \\
&\quad + (r_{m'm,ir\beta} + r_{1m',ir\beta} e^{2i\beta_{m',ir} h_{m''}}) (r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2\beta_{m',ir} h_{m''}}) e^{2i\beta_{m,ir} h_m}\}} \\
&\times \exp[i(h_m \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF}) (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \\
&\times \exp[i(2n+1)(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF}) (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \quad (3.7)
\end{aligned}$$

 E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
E_{vis\alpha}(h_{m'}^+)E_{ir\beta}(h_{m'}^+) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
&\times \frac{t_{1m'vis\alpha} t_{m'm,vis\alpha} e^{\beta_{m',vis} h_{m'}} [(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) + (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2\beta_{m,vis} h_m}]}{\{(1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2\beta_{m',vis} h_{m'}}) (1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) \\
&\quad + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis} h_{m'}}) (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis} h_{m''}}) e^{2i\beta_{m,vis} h_m}\}}
\end{aligned}$$

$$\begin{aligned}
& \times \frac{t_{1m'jr,\beta} t_{m'mjr,\beta} e^{i\beta_{m',ir}h_{m'}} [(1+r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) + (r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) e^{2i\beta_{m',ir}h_{m'}}]}{\{(1+r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) \\
& \quad + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) e^{2i\beta_{m',ir}h_{m'}}\}} \\
& \times \exp[ih_{m'} \tan\theta_{m'SF} (-k_{m'jr} \sin\theta_{m'jr} - k_{m'vis} \sin\theta_{m'vis})] \\
& \times \exp[i2n(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF}) (-k_{m'jr} \sin\theta_{m'jr} - k_{m'vis} \sin\theta_{m'vis})] \quad (3.8)
\end{aligned}$$

m/m'' 界面の m 側：

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
& E_{vis\alpha} (h_m + h_{m'}^-) E_{ir,\beta} (h_m + h_{m'}^-) = E_{vis\alpha}^0 E_{ir,\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i(\beta_{m',vis}h_m + \beta_{m'vis}h_{m'})} (1+r_{mm''vis\alpha})(1+r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m'}})}{\{(1+r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1+r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) \\
& \quad + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) e^{2i\beta_{m',vis}h_{m'}}\}} \\
& \times \frac{t_{1m'jr,\beta} t_{m'mjr,\beta} e^{i(\beta_{m',ir}h_m + \beta_{m'ir}h_{m'})} (1+r_{mm''jr,\beta})(1+r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}})}{\{(1+r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) \\
& \quad + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) e^{2i\beta_{m',ir}h_{m'}}\}} \\
& \times \exp[ih_{m''} \tan\theta_{m'SF} (-k_{m'jr} \sin\theta_{m'jr} - k_{m'vis} \sin\theta_{m'vis})] \\
& \times \exp[i(2n+1)(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF}) (-k_{m'jr} \sin\theta_{m'jr} - k_{m'vis} \sin\theta_{m'vis})] \quad (3.9)
\end{aligned}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
& E_{vis\alpha} (h_m + h_{m'}^-) E_{ir,\beta} (h_m + h_{m'}^-) = E_{vis\alpha}^0 E_{ir,\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i(\beta_{m',vis}h_m + \beta_{m'vis}h_{m'})} (1+r_{mm''vis\alpha})(1+r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m'}})}{\{(1+r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1+r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) \\
& \quad + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m'}}) e^{2i\beta_{m',vis}h_{m'}}\}} \\
& \times \frac{t_{1m'jr,\beta} t_{m'mjr,\beta} e^{i(\beta_{m',ir}h_m + \beta_{m'ir}h_{m'})} (1+r_{mm''jr,\beta})(1+r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}})}{\{(1+r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) \\
& \quad + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m'}}) e^{2i\beta_{m',ir}h_{m'}}\}} \\
& \times \exp[i(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF}) (-k_{m'jr} \sin\theta_{m'jr} - k_{m'vis} \sin\theta_{m'vis})] \\
& \times \exp[i2n(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF}) (-k_{m'jr} \sin\theta_{m'jr} - k_{m'vis} \sin\theta_{m'vis})] \quad (3.10)
\end{aligned}$$

m/m'' 界面の m'' 側：

E^+ and E^- (by reflection and transmission) sources

$$E_{vis\alpha} (h_m + h_{m'}^+) E_{ir,\beta} (h_m + h_{m'}^+) = E_{vis\alpha}^0 E_{ir,\beta}^0$$

$$\begin{aligned}
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} t_{mm''vis\alpha} e^{i(\beta_{m'vis} h_m + \beta_{m'vis} h_{m'})} (1 + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}})}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} t_{mm''jr\beta} e^{i(\beta_{m'jr} h_m + \beta_{m'jr} h_{m'})} (1 + r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}})}{\{(1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}} \\
& \times \exp[ih_m \tan \theta_{m'SF} - k_{m'jr} \sin \theta_{m'jr} - k_{m'vis} \sin \theta_{m'vis}] \\
& \times \exp[i(2n+1)(h_m \tan \theta_{m'SF} + h_{m'} \tan \theta_{m'SF} + h_{m''} \tan \theta_{m'SF}) - (k_{m'jr} \sin \theta_{m'jr} - k_{m'vis} \sin \theta_{m'vis})]
\end{aligned} \tag{3.11}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
E_{vis\alpha}(h_m + h_{m'}) E_{ir\beta}(h_m + h_{m'}) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} t_{mm''vis\alpha} e^{i(\beta_{m'vis} h_m + \beta_{m'vis} h_{m'})} (1 + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}})}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} t_{mm''jr\beta} e^{i(\beta_{m'jr} h_m + \beta_{m'jr} h_{m'})} (1 + r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}})}{\{(1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}} \\
& \times \exp[i(h_m \tan \theta_{m'SF} + h_{m'} \tan \theta_{m'SF}) - (k_{m'jr} \sin \theta_{m'jr} - k_{m'vis} \sin \theta_{m'vis})] \\
& \times \exp[i2n(h_m \tan \theta_{m'SF} + h_{m'} \tan \theta_{m'SF} + h_{m''} \tan \theta_{m'SF}) - (k_{m'jr} \sin \theta_{m'jr} - k_{m'vis} \sin \theta_{m'vis})]
\end{aligned} \tag{3.12}$$

m' 層の深さ z_1 点:

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
E_{vis\alpha}(z_1) E_{ir\beta}(z_1) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha}}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
& \times \frac{t_{1m'jr\beta}}{\{(1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}} \\
& \times \{[(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'vis} h_{m'}}) + r_{m'mvis\alpha} (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}] \\
& \times \exp[iz_1 (k_{m'vis} \cos \theta_{m'vis} (1 + \tan \theta_{m'SF} \tan \theta_{m'vis}))] \\
& + [r_{m'mvis\alpha} (1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) + (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}] \\
& \times \exp[iz_1 (k_{m'vis} \cos \theta_{m'vis} (-1 + \tan \theta_{m'SF} \tan \theta_{m'vis}))]\} \\
& \times \{[(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) + r_{m'mjr\beta} (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}]
\end{aligned}$$

$$\begin{aligned}
& \times \exp[iz_1(k_{m'jr} \cos\theta_{m'SF} (1 + \tan\theta_{m'SF} \tan\theta_{mir})) \\
& + [r_{m'm'jr\beta} (1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) + (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) e^{2\beta_{m'jr} h_m}] \\
& \times \exp[iz_1(k_{m'jr} \cos\theta_{m'jr} (-1 + \tan\theta_{m'SF} \tan\theta_{mir}))] \\
& \times \exp[i(2n+2)(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF})(-k_{m'jr} \sin\theta_{mir} - k_{m'vis} \sin\theta_{m'vis})]
\end{aligned} \tag{3.13}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
E_{vis\alpha}(z_1)E_{ir\beta}(z_1) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha}}{\{(1 + r_{1m'vis\alpha} r_{m'm'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'm'vis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
& \times \frac{t_{1m'jr\beta}}{\{(1 + r_{1m'jr\beta} r_{m'm'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) \\
& + (r_{m'm'jr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}} \\
& \times \{[(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'vis} h_{m'}}) + r_{m'm'vis\alpha} (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}] \\
& \times \exp[iz_1(k_{m'vis} \cos\theta_{m'vis} (1 - \tan\theta_{m'SF} \tan\theta_{m'vis}))] \\
& + [r_{m'm'vis\alpha} (1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) + (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}] \\
& \times \exp[iz_1(k_{m'vis} \cos\theta_{m'vis} (-1 - \tan\theta_{m'SF} \tan\theta_{m'vis}))] \\
& \times \{[(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) + r_{m'm'jr\beta} (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}] \\
& \times \exp[iz_1(k_{m'jr} \cos\theta_{m'jr} (1 - \tan\theta_{m'SF} \tan\theta_{mir}))] \\
& + [r_{m'm'jr\beta} (1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) + (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) e^{2\beta_{m'jr} h_m}] \\
& \times \exp[iz_1(k_{m'jr} \cos\theta_{m'jr} (-1 - \tan\theta_{m'SF} \tan\theta_{mir}))] \\
& \times \exp[i2n(h_m \tan\theta_{m'SF} + h_{m'} \tan\theta_{m'SF} + h_{m''} \tan\theta_{m'SF})(-k_{m'jr} \sin\theta_{mir} - k_{m'vis} \sin\theta_{m'vis})]
\end{aligned} \tag{3.14}$$

m 層の m'/m 界面から深さ z_2 の点 :

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
E_{vis\alpha}(h_{m'} + z_2)E_{ir\beta}(h_{m'} + z_2) &= E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'm'vis\alpha} e^{i\beta_{m'vis} h_{m'}}}{\{(1 + r_{1m'vis\alpha} r_{m'm'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'm'vis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
& \times \frac{t_{1m'jr\beta} t_{m'm'jr\beta} e^{i\beta_{m'jr} h_{m'}}}{\{(1 + r_{1m'jr\beta} r_{m'm'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) \\
& + (r_{m'm'jr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}} \\
& \times \{(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'vis} h_{m'}}) \exp[iz_2(k_{m'vis} \cos\theta_{m'vis} (1 + \tan\theta_{m'SF} \tan\theta_{m'vis}))] \\
& + (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m} \exp[iz_2(k_{m'vis} \cos\theta_{m'vis} (-1 + \tan\theta_{m'SF} \tan\theta_{m'vis}))]\} \\
& \times \{(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) \exp[iz_2(k_{m'jr} \cos\theta_{m'jr} (1 + \tan\theta_{m'SF} \tan\theta_{mir}))] \\
& + (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2\beta_{m'jr} h_{m'}}) e^{2\beta_{m'jr} h_m} \exp[iz_2(k_{m'jr} \cos\theta_{m'jr} (-1 + \tan\theta_{m'SF} \tan\theta_{mir}))]\}
\end{aligned}$$

$$\times \exp[i(2n+2)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \quad (3.15)$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned} E_{vis\alpha}(h_{m'} + z_2)E_{ir,\beta}(h_{m'} + z_2) &= E_{vis\alpha}^0 E_{ir,\beta}^0 \\ &\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} e^{i\beta_{m',vis} h_{m'}}}{\{(1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2\beta_{m',vis} h_{m'}})(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2\beta_{m'',vis} h_{m''}}) \\ &\quad + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis} h_{m'}})(r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2\beta_{m'',vis} h_{m''}}) e^{2i\beta_{m,vis} h_m}\}} \\ &\times \frac{t_{1m',ir,\beta} t_{m'm,ir,\beta} e^{i\beta_{m',ir} h_{m'}}}{\{(1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) \\ &\quad + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) e^{2i\beta_{m,ir} h_m}\}} \\ &\times \{(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m'',vis} h_{m''}}) \exp[iz_2(k_{m,vis} \cos\theta_{m,vis}(1 - \tan\theta_{m,SF} \tan\theta_{m,vis}))] \\ &\quad + (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m'',vis} h_{m''}}) e^{2\beta_{m,vis} h_m} \exp[iz_2(k_{m,vis} \cos\theta_{m,vis}(-1 - \tan\theta_{m,SF} \tan\theta_{m,vis}))]\} \\ &\times \{(1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) \exp[iz_2(k_{m,ir} \cos\theta_{m,ir}(1 - \tan\theta_{m,SF} \tan\theta_{m,ir}))] \\ &\quad + (r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) e^{2\beta_{m,ir} h_m} \exp[iz_2(k_{m,ir} \cos\theta_{m,ir}(-1 - \tan\theta_{m,SF} \tan\theta_{m,ir}))]\} \\ &\times \exp[i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (3.16)$$

m'' 層の m/m'' 界面から深さ z_3 の点 :

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned} E_{vis\alpha}(h_{m'} + h_m + z_3)E_{ir,\beta}(h_{m'} + h_m + z_3) &= E_{vis\alpha}^0 E_{ir,\beta}^0 \\ &\times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} t_{mm'',vis\alpha} e^{i(\beta_{m,vis} h_m + \beta_{m',vis} h_{m'})}}{\{(1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2\beta_{m',vis} h_{m'}})(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2\beta_{m'',vis} h_{m''}}) \\ &\quad + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2\beta_{m',vis} h_{m'}})(r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2\beta_{m'',vis} h_{m''}}) e^{2i\beta_{m,vis} h_m}\}} \\ &\times \frac{t_{1m',ir,\beta} t_{m'm,ir,\beta} t_{mm'',ir,\beta} e^{i(\beta_{m,ir} h_m + \beta_{m',ir} h_{m'})}}{\{(1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) \\ &\quad + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) e^{2i\beta_{m,ir} h_m}\}} \\ &\times \{\exp[iz_3(k_{m',vis} \cos\theta_{m',vis}(1 + \tan\theta_{m'',SF} \tan\theta_{m',vis}))] \\ &\quad + r_{m''2,vis\alpha} e^{2i(\beta_{m,vis} h_m + \beta_{m'',vis} h_{m''})} \exp[iz_3(k_{m',vis} \cos\theta_{m',vis}(-1 + \tan\theta_{m'',SF} \tan\theta_{m',vis}))]\} \\ &\times \{\exp[iz_3(k_{m',ir} \cos\theta_{m',ir}(1 + \tan\theta_{m'',SF} \tan\theta_{m',ir}))] \\ &\quad + r_{m''2,ir,\beta} e^{2i(\beta_{m,ir} h_m + \beta_{m'',ir} h_{m''})} \exp[iz_3(k_{m',ir} \cos\theta_{m',ir}(-1 + \tan\theta_{m'',SF} \tan\theta_{m',ir}))]\} \\ &\times \exp[i(2n+2)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \end{aligned} \quad (3.17)$$

E^+ (by reflection and transmission) and E^- sources

$$E_{vis\alpha}(h_{m'} + h_m + z_3)E_{ir,\beta}(h_{m'} + h_m + z_3) = E_{vis\alpha}^0 E_{ir,\beta}^0$$

$$\begin{aligned}
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} t_{mm'vis\alpha} e^{i(\beta_{m'vis} h_m + \beta_{m'vis} h_{m'})}}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} t_{mm'jr\beta} e^{i(\beta_{m'jr} h_m + \beta_{m'jr} h_{m'})}}{\{(1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm'jr\beta} r_{m'2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(r_{mm'jr\beta} + r_{m'2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}} \\
& \times \{ \exp[i z_3 (k_{m'vis} \cos \theta_{m'vis} (1 - \tan \theta_{m'SF} \tan \theta_{m'vis})) \\
& + r_{m'2vis\alpha} e^{2i(\beta_{m'vis} h_m + \beta_{m'vis} h_{m'})} \exp[i z_3 (k_{m'vis} \cos \theta_{m'vis} (-1 - \tan \theta_{m'SF} \tan \theta_{m'vis}))] \} \\
& \times \{ \exp[i z_3 (k_{m'jr} \cos \theta_{m'jr} (1 - \tan \theta_{m'SF} \tan \theta_{m'jr})) \\
& + r_{m'2jr\beta} e^{2i(\beta_{m'jr} h_m + \beta_{m'jr} h_{m'})} \exp[i z_3 (k_{m'jr} \cos \theta_{m'jr} (-1 - \tan \theta_{m'SF} \tan \theta_{m'jr}))] \} \\
& \times \exp[i 2n (h_m \tan \theta_{m'SF} + h_{m'} \tan \theta_{m'SF} + h_{m''} \tan \theta_{m'SF}) (-k_{m'jr} \sin \theta_{m'jr} - k_{m'vis} \sin \theta_{m'vis})] \quad (3.18)
\end{aligned}$$

3.2. SFG 分極

上で求めた電場積に SFG 感受率を掛けたものが SFG 分極になる。

これから先は恐ろしく複雑である。どれかの層が無限に薄いときにのみ、表式が得られるであろう。

1/m' 界面の 1 側：

E^+ (by reflection and transmission) and E^- (for $n = 0$) sources

$$\begin{aligned}
P_a^* (0^-) &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{\{(1 + r_{1m'vis\alpha} e^{2i\beta_{m'vis} h_{m'}})(1 + r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + e^{2\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
& \times \frac{\{(1 + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{m'mjr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm'jr\beta} r_{m'2jr\beta} e^{2\beta_{m'jr} h_{m'}}) \\
& + (r_{m'mjr\beta} + e^{2i\beta_{m'jr} h_{m'}})(r_{mm'jr\beta} + r_{m'2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}}{\{(1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'jr} h_{m'}})(1 + r_{mm'jr\beta} r_{m'2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'jr} h_{m'}})(r_{mm'jr\beta} + r_{m'2jr\beta} e^{2i\beta_{m'jr} h_{m'}}) e^{2i\beta_{m'jr} h_m}\}} \quad (3.19)
\end{aligned}$$

1/m' 界面の m' 側：

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
P_a^* (0^+) &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{\{t_{1m'vis\alpha} [(1 + r_{m'mvis\alpha} e^{2i\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + e^{2i\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2i\beta_{m'vis} h_{m'}}) e^{2\beta_{m'vis} h_m}\}}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}}
\end{aligned}$$

$$\begin{aligned}
& \{ t_{1m'jr\beta} [(1 + r_{mm'jr\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m',ir}h_{m'}}) \\
& + (r_{m'mjr\beta} + e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m',ir}h_{m'}}) e^{2i\beta_{m',ir}h_{m'}}] \} \\
& \times \frac{\{ (1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m',ir}h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m',ir}h_{m'}}) e^{2i\beta_{m',ir}h_{m'}} \}}
\end{aligned} \tag{3.20}$$

m''/2 界面の2 側 :

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^* (h_{m'} + h_m + h_{m''}^+) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} \\
& \times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} t_{mm'',vis\alpha} t_{m''2,vis\alpha} e^{i(\beta_{m',vis}h_{m'} + \beta_{m,vis}h_m + \beta_{m'',vis}h_{m''})}}{\{ (1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) \\
& + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) e^{2i\beta_{m',vis}h_{m'}} \}} \\
& \times \frac{t_{1m'jr\beta} t_{m'm,ir\beta} t_{mm'',ir\beta} t_{m''2,ir\beta} e^{i(\beta_{m',ir}h_{m'} + \beta_{m,ir}h_m + \beta_{m'',ir}h_{m''})}}{\{ (1 + r_{1m'jr\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir}h_{m''}}) \\
& + (r_{m'm,ir\beta} + r_{1m'jr\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir}h_{m''}}) e^{2i\beta_{m',ir}h_{m'}} \}}
\end{aligned} \tag{3.21}$$

m''/2 界面の m'' 側 :

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^* (h_{m'} + h_m + h_{m''}^-) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} \\
& \times \frac{t_{1m',vis\alpha} t_{m'm,vis\alpha} t_{mm'',vis\alpha} (1 + r_{m''2,vis\alpha}) e^{i(\beta_{m',vis}h_{m'} + \beta_{m,vis}h_m + \beta_{m'',vis}h_{m''})}}{\{ (1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) \\
& + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) e^{2i\beta_{m',vis}h_{m'}} \}} \\
& \times \frac{t_{1m'jr\beta} t_{m'm,ir\beta} t_{mm'',ir\beta} (1 + r_{m''2,ir\beta}) e^{i(\beta_{m',ir}h_{m'} + \beta_{m,ir}h_m + \beta_{m'',ir}h_{m''})}}{\{ (1 + r_{1m'jr\beta} r_{m'm,ir\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm'',ir\beta} r_{m''2,ir\beta} e^{2i\beta_{m',ir}h_{m''}}) \\
& + (r_{m'm,ir\beta} + r_{1m'jr\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir\beta} + r_{m''2,ir\beta} e^{2i\beta_{m',ir}h_{m''}}) e^{2i\beta_{m',ir}h_{m'}} \}}
\end{aligned} \tag{3.22}$$

m'/m 界面の m' 側 :

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
P_a^* (h_{m'}^-) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} \\
& \times \frac{\{ t_{1m',vis\alpha} e^{i\beta_{m',vis}h_{m'}} (1 + r_{m'm,vis\alpha}) [(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) \\
& + (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) e^{2i\beta_{m',vis}h_{m''}}] \}}{\{ (1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) \\
& + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) e^{2i\beta_{m',vis}h_{m''}} \}}
\end{aligned}$$

$$\begin{aligned}
& \{ t_{1m'jr\beta} e^{i\beta_{m'} h_{m'}} (1 + r_{m'mjr\beta}) [(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mjr\beta} + e^{2i\beta_{m'} h_{m'}}) (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}}] \} \\
& \times \frac{\{ (1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'} h_{m'}}) (1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'} h_{m'}}) (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}} \}}{e^{2i\beta_{m'} h_{m'}}} \quad (3.23)
\end{aligned}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^* (h_{m'}^-) &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \{ t_{1m'vis\alpha} e^{i\beta_{m'} h_{m'}} (1 + r_{m'mvis\alpha}) [(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}}] \} \\
& \times \frac{\{ (1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'} h_{m'}}) (1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'} h_{m'}}) (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}} \}}{e^{2i\beta_{m'} h_{m'}}} \\
& \{ t_{1m'jr\beta} e^{i\beta_{m'} h_{m'}} (1 + r_{m'mjr\beta}) [(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mjr\beta} + e^{2i\beta_{m'} h_{m'}}) (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}}] \} \\
& \times \frac{\{ (1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'} h_{m'}}) (1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'} h_{m'}}) (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}} \}}{e^{2i\beta_{m'} h_{m'}}} \quad (3.24)
\end{aligned}$$

m'/m 界面 の m 側 :

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
P_a^* (h_{m'}^+) &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i\beta_{m'} h_{m'}} [(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) + (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}}] \\
& \{ (1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'} h_{m'}}) (1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'} h_{m'}}) (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}} \}}{e^{2i\beta_{m'} h_{m'}}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} e^{i\beta_{m'} h_{m'}} [(1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) + (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}}] \\
& \{ (1 + r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m'} h_{m'}}) (1 + r_{mm''jr\beta} r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m'} h_{m'}}) (r_{mm''jr\beta} + r_{m''2jr\beta} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}} \}}{e^{2i\beta_{m'} h_{m'}}} \quad (3.25)
\end{aligned}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^* (h_{m'}^+) &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i\beta_{m'} h_{m'}} [(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) + (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}}] \\
& \{ (1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m'} h_{m'}}) (1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m'} h_{m'}}) (r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m'} h_{m'}}) e^{2i\beta_{m'} h_{m'}} \}}{e^{2i\beta_{m'} h_{m'}}}
\end{aligned}$$

$$\times \frac{t_{1m'jr,\beta} t_{m'mjr,\beta} e^{i\beta_{m',ir}h_{m'}} [(1 + r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}}) + (r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}}) e^{2i\beta_{m',ir}h_{m'}}]}{\{(1 + r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}})\} + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}}) e^{2i\beta_{m',ir}h_{m'}}} \quad (3.26)$$

m/m'' 界面の m 側：

E^+ and E^- (by reflection and transmission) sources

$$P_a^*(h_m + h_{m'}) = \sum_{\alpha,\beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir,\beta}^0$$

$$\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i(\beta_{m',vis}h_m + \beta_{m,vis}h_{m'})} (1 + r_{mm''vis\alpha}) (1 + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}})}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}})\} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) e^{2i\beta_{m',vis}h_{m'}}}$$

$$\times \frac{t_{1m'jr,\beta} t_{m'mjr,\beta} e^{i(\beta_{m',ir}h_m + \beta_{m,ir}h_{m'})} (1 + r_{mm''jr,\beta}) (1 + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}})}{\{(1 + r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}})\} + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}}) e^{2i\beta_{m',ir}h_{m'}}} \quad (3.27)$$

E^+ (by reflection and transmission) and E^- sources

$$P_a^*(h_m + h_{m'}) = \sum_{\alpha,\beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir,\beta}^0$$

$$\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} e^{i(\beta_{m',vis}h_m + \beta_{m,vis}h_{m'})} (1 + r_{mm''vis\alpha}) (1 + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}})}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}})\} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) e^{2i\beta_{m',vis}h_{m'}}}$$

$$\times \frac{t_{1m'jr,\beta} t_{m'mjr,\beta} e^{i(\beta_{m',ir}h_m + \beta_{m,ir}h_{m'})} (1 + r_{mm''jr,\beta}) (1 + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}})}{\{(1 + r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}})\} + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}}) e^{2i\beta_{m',ir}h_{m'}}} \quad (3.28)$$

m/m'' 界面の m'' 側：

E^+ and E^- (by reflection and transmission) sources

$$P_a^*(h_m + h_{m'}) = \sum_{\alpha,\beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir,\beta}^0$$

$$\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} t_{mm''vis\alpha} e^{i(\beta_{m,vis}h_m + \beta_{m',vis}h_{m'})} (1 + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}})}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis}h_{m'}})(1 + r_{mm''vis\alpha} r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}})\} + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_{m'}})(r_{mm''vis\alpha} + r_{m''2vis\alpha} e^{2i\beta_{m',vis}h_{m''}}) e^{2i\beta_{m',vis}h_{m''}}}$$

$$\times \frac{t_{1m'jr,\beta} t_{m'mjr,\beta} t_{mm''jr,\beta} e^{i(\beta_{m,ir}h_m + \beta_{m',ir}h_{m'})} (1 + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}})}{\{(1 + r_{1m'jr,\beta} r_{m'mjr,\beta} e^{2i\beta_{m',ir}h_{m'}})(1 + r_{mm''jr,\beta} r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}})\} + (r_{m'mjr,\beta} + r_{1m'jr,\beta} e^{2i\beta_{m',ir}h_{m'}})(r_{mm''jr,\beta} + r_{m''2jr,\beta} e^{2i\beta_{m',ir}h_{m''}}) e^{2i\beta_{m',ir}h_{m''}}}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^*(h_m + h_{m'}^+) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} \\
&\times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} t_{mm'vis\alpha} e^{i(\beta_{m'vis} h_m + \beta_{mvis} h_{m'})} (1 + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}})}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
&\quad + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
&\times \frac{t_{1m'ir\beta} t_{m'mir\beta} t_{mm'ir\beta} e^{i(\beta_{m'ir} h_m + \beta_{m'ir} h_{m'})} (1 + r_{m'2ir\beta} e^{2\beta_{m'ir} h_{m'}})}{\{(1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m'ir} h_{m'}})(1 + r_{mm'ir\beta} r_{m'2ir\beta} e^{2i\beta_{m'ir} h_{m'}}) \\
&\quad + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m'ir} h_{m'}})(r_{mm'ir\beta} + r_{m'2ir\beta} e^{2i\beta_{m'ir} h_{m'}}) e^{2i\beta_{m'ir} h_m}\}}
\end{aligned} \tag{3.30}$$

m' 層の深さ z_1 点:

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
P_a^*(z_1) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} \\
&\times \frac{t_{1m'vis\alpha}}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
&\quad + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}} \\
&\times \frac{t_{1m'ir\beta}}{\{(1 + r_{1m'ir\beta} r_{m'mir\beta} e^{2i\beta_{m'ir} h_{m'}})(1 + r_{mm'ir\beta} r_{m'2ir\beta} e^{2i\beta_{m'ir} h_{m'}}) \\
&\quad + (r_{m'mir\beta} + r_{1m'ir\beta} e^{2i\beta_{m'ir} h_{m'}})(r_{mm'ir\beta} + r_{m'2ir\beta} e^{2i\beta_{m'ir} h_{m'}}) e^{2i\beta_{m'ir} h_m}\}} \\
&\times \{[(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2i\beta_{m'vis} h_{m'}}) + r_{m'mvis\alpha} (r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}] \\
&\times \exp[iz_1 (k_{m'vis} \cos\theta_{m'vis} (1 + \tan\theta_{m'SF} \tan\theta_{m'vis}))] \\
&\quad + [r_{m'mvis\alpha} (1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) + (r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}] \\
&\times \exp[iz_1 (k_{m'vis} \cos\theta_{m'vis} (-1 + \tan\theta_{m'SF} \tan\theta_{m'vis}))]\} \\
&\times \{[(1 + r_{mm'ir\beta} r_{m'2ir\beta} e^{2i\beta_{m'ir} h_{m'}}) + r_{m'mir\beta} (r_{mm'ir\beta} + r_{m'2ir\beta} e^{2\beta_{m'ir} h_{m'}}) e^{2i\beta_{m'ir} h_m}] \\
&\times \exp[iz_1 (k_{m'ir} \cos\theta_{m'ir} (1 + \tan\theta_{m'SF} \tan\theta_{m'ir}))] \\
&\quad + [r_{m'mir\beta} (1 + r_{mm'ir\beta} r_{m'2ir\beta} e^{2\beta_{m'ir} h_{m'}}) + (r_{mm'ir\beta} + r_{m'2ir\beta} e^{2\beta_{m'ir} h_{m'}}) e^{2\beta_{m'ir} h_m}] \\
&\times \exp[iz_1 (k_{m'ir} \cos\theta_{m'ir} (-1 + \tan\theta_{m'SF} \tan\theta_{m'ir}))]\}
\end{aligned} \tag{3.31}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^*(z_1) &= \sum_{\alpha, \beta} \chi_{\alpha\beta} E^0_{vis\alpha} E^0_{ir\beta} \\
&\times \frac{t_{1m'vis\alpha}}{\{(1 + r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2\beta_{m'vis} h_{m'}})(1 + r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) \\
&\quad + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2\beta_{m'vis} h_{m'}})(r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2\beta_{m'vis} h_{m'}}) e^{2i\beta_{m'vis} h_m}\}}
\end{aligned}$$

$$\begin{aligned}
& \times \frac{t_{1m'jr\beta}}{\{(1+r_{1m'jr\beta}r_{m'mjr\beta}e^{2i\beta_{m'jr}h_{m'}})(1+r_{mm''jr\beta}r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}}) \\
& \quad + (r_{m'mjr\beta}+r_{1m'jr\beta}e^{2i\beta_{m'jr}h_{m'}})(r_{mm''jr\beta}+r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})e^{2i\beta_{m'jr}h_{m'}}\}} \\
& \times \{[(1+r_{mm''vis\alpha}r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})+r_{m'mvis\alpha}(r_{mm''vis\alpha}+r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{m'vis}h_{m'}}] \\
& \times \exp[iz_1(k_{m'vis}\cos\theta_{m'vis}(1-\tan\theta_{m'SF}\tan\theta_{m'vis}))] \\
& \quad + [r_{m'mvis\alpha}(1+r_{mm''vis\alpha}r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})+(r_{mm''vis\alpha}+r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{m'vis}h_{m'}}] \\
& \times \exp[iz_1(k_{m'vis}\cos\theta_{m'vis}(-1-\tan\theta_{m'SF}\tan\theta_{m'vis}))]\} \\
& \times \{[(1+r_{mm''jr\beta}r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})+r_{m'mjr\beta}(r_{mm''jr\beta}+r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})e^{2i\beta_{m'jr}h_{m'}}] \\
& \times \exp[iz_1(k_{m'jr}\cos\theta_{m'jr}(1-\tan\theta_{m'SF}\tan\theta_{m'jr}))] \\
& \quad + [r_{m'mjr\beta}(1+r_{mm''jr\beta}r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})+(r_{mm''jr\beta}+r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})e^{2i\beta_{m'jr}h_{m'}}] \\
& \times \exp[iz_1(k_{m'jr}\cos\theta_{m'jr}(-1-\tan\theta_{m'SF}\tan\theta_{m'jr}))]\} \tag{3.32}
\end{aligned}$$

m 層の m'/m 界面から深さ z_2 の点 :

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
P_a^*(h_{m'}+z_2) &= \sum_{\alpha\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha}t_{m'mvis\alpha}e^{i\beta_{m'vis}h_{m'}}}{\{(1+r_{1m'vis\alpha}r_{m'mvis\alpha}e^{2i\beta_{m'vis}h_{m'}})(1+r_{mm''vis\alpha}r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}}) \\
& \quad + (r_{m'mvis\alpha}+r_{1m'vis\alpha}e^{2i\beta_{m'vis}h_{m'}})(r_{mm''vis\alpha}+r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{m'vis}h_{m'}}\}} \\
& \times \frac{t_{1m'jr\beta}t_{m'mjr\beta}e^{i\beta_{m'jr}h_{m'}}}{\{(1+r_{1m'jr\beta}r_{m'mjr\beta}e^{2i\beta_{m'jr}h_{m'}})(1+r_{mm''jr\beta}r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}}) \\
& \quad + (r_{m'mjr\beta}+r_{1m'jr\beta}e^{2i\beta_{m'jr}h_{m'}})(r_{mm''jr\beta}+r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})e^{2i\beta_{m'jr}h_{m'}}\}} \\
& \times \{(1+r_{mm''vis\alpha}r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})\exp[iz_2(k_{m'vis}\cos\theta_{m'vis}(1+\tan\theta_{m'SF}\tan\theta_{m'vis}))] \\
& \quad + (r_{mm''vis\alpha}+r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{m'vis}h_{m'}}\exp[iz_2(k_{m'vis}\cos\theta_{m'vis}(-1+\tan\theta_{m'SF}\tan\theta_{m'vis}))]\} \\
& \times \{(1+r_{mm''jr\beta}r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})\exp[iz_2(k_{m'jr}\cos\theta_{m'jr}(1+\tan\theta_{m'SF}\tan\theta_{m'jr}))] \\
& \quad + (r_{mm''jr\beta}+r_{m''2jr\beta}e^{2i\beta_{m''jr}h_{m''}})e^{2i\beta_{m'jr}h_{m'}}\exp[iz_2(k_{m'jr}\cos\theta_{m'jr}(-1+\tan\theta_{m'SF}\tan\theta_{m'jr}))]\} \tag{3.33}
\end{aligned}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^*(h_{m'}+z_2) &= \sum_{\alpha\beta} \chi_{\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha}t_{m'mvis\alpha}e^{i\beta_{m'vis}h_{m'}}}{\{(1+r_{1m'vis\alpha}r_{m'mvis\alpha}e^{2i\beta_{m'vis}h_{m'}})(1+r_{mm''vis\alpha}r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}}) \\
& \quad + (r_{m'mvis\alpha}+r_{1m'vis\alpha}e^{2i\beta_{m'vis}h_{m'}})(r_{mm''vis\alpha}+r_{m''2vis\alpha}e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{m'vis}h_{m'}}\}}
\end{aligned}$$

$$\begin{aligned}
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} e^{i\beta_{m',ir}h_m}}{\{(1+r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m',ir}h_m})(1+r_{mm'jr\beta} r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m',ir}h_m})(r_{mm'jr\beta} + r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m}) e^{2i\beta_{m',ir}h_m}\}} \\
& \times \{(1+r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2i\beta_{m',vis}h_m}) \exp[iz_2(k_{m,vis} \cos\theta_{m,vis}(1-\tan\theta_{m,SF} \tan\theta_{m,vis}))] \\
& + (r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2i\beta_{m',vis}h_m}) e^{2i\beta_{m',vis}h_m} \exp[iz_2(k_{m,vis} \cos\theta_{m,vis}(-1-\tan\theta_{m,SF} \tan\theta_{m,vis}))]\} \\
& \times \{(1+r_{mm'jr\beta} r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m}) \exp[iz_2(k_{m,ir} \cos\theta_{m,ir}(1-\tan\theta_{m,SF} \tan\theta_{m,ir}))] \\
& + (r_{mm'jr\beta} + r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m}) e^{2i\beta_{m',ir}h_m} \exp[iz_2(k_{m,ir} \cos\theta_{m,ir}(-1-\tan\theta_{m,SF} \tan\theta_{m,ir}))]\} \quad (3.34)
\end{aligned}$$

m'' 層の m/m'' 界面から深さ z_3 の点 :

E^+ and E^- (by reflection and transmission) sources

$$\begin{aligned}
P_a^*(h_m' + h_m + z_3) &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} t_{mm'vis\alpha} e^{i(\beta_{m',vis}h_m + \beta_{m',vis}h_m')}}{\{(1+r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis}h_m'}) (1+r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2i\beta_{m',vis}h_m'}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_m'}) (r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2i\beta_{m',vis}h_m'}) e^{2i\beta_{m',vis}h_m}\}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} t_{mm'jr\beta} e^{i(\beta_{m',ir}h_m + \beta_{m',ir}h_m')}}{\{(1+r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m',ir}h_m'}) (1+r_{mm'jr\beta} r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m'}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m',ir}h_m'}) (r_{mm'jr\beta} + r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m'}) e^{2i\beta_{m',ir}h_m}\}} \\
& \times \{\exp[iz_3(k_{m',vis} \cos\theta_{m',vis}(1+\tan\theta_{m',SF} \tan\theta_{m',vis}))] \\
& + r_{m'2vis\alpha} e^{2i(\beta_{m',vis}h_m + \beta_{m',vis}h_m')} \exp[iz_3(k_{m',vis} \cos\theta_{m',vis}(-1+\tan\theta_{m',SF} \tan\theta_{m',vis}))]\} \\
& \times \{\exp[iz_3(k_{m',jr} \cos\theta_{m',jr}(1+\tan\theta_{m',SF} \tan\theta_{m',jr}))] \\
& + r_{m'2jr\beta} e^{2i(\beta_{m',ir}h_m + \beta_{m',ir}h_m')} \exp[iz_3(k_{m',jr} \cos\theta_{m',jr}(-1+\tan\theta_{m',SF} \tan\theta_{m',jr}))]\} \quad (3.35)
\end{aligned}$$

E^+ (by reflection and transmission) and E^- sources

$$\begin{aligned}
P_a^*(h_m' + h_m + z_3) &= \sum_{\alpha, \beta} \chi_{\alpha\alpha\beta} E_{vis\alpha}^0 E_{ir\beta}^0 \\
& \times \frac{t_{1m'vis\alpha} t_{m'mvis\alpha} t_{mm'vis\alpha} e^{i(\beta_{m',vis}h_m + \beta_{m',vis}h_m')}}{\{(1+r_{1m'vis\alpha} r_{m'mvis\alpha} e^{2i\beta_{m',vis}h_m'}) (1+r_{mm'vis\alpha} r_{m'2vis\alpha} e^{2i\beta_{m',vis}h_m'}) \\
& + (r_{m'mvis\alpha} + r_{1m'vis\alpha} e^{2i\beta_{m',vis}h_m'}) (r_{mm'vis\alpha} + r_{m'2vis\alpha} e^{2i\beta_{m',vis}h_m'}) e^{2i\beta_{m',vis}h_m}\}} \\
& \times \frac{t_{1m'jr\beta} t_{m'mjr\beta} t_{mm'jr\beta} e^{i(\beta_{m',ir}h_m + \beta_{m',ir}h_m')}}{\{(1+r_{1m'jr\beta} r_{m'mjr\beta} e^{2i\beta_{m',ir}h_m'}) (1+r_{mm'jr\beta} r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m'}) \\
& + (r_{m'mjr\beta} + r_{1m'jr\beta} e^{2i\beta_{m',ir}h_m'}) (r_{mm'jr\beta} + r_{m'2jr\beta} e^{2i\beta_{m',ir}h_m'}) e^{2i\beta_{m',ir}h_m}\}} \\
& \times \{\exp[iz_3(k_{m',vis} \cos\theta_{m',vis}(1-\tan\theta_{m',SF} \tan\theta_{m',vis}))] \\
& + r_{m'2vis\alpha} e^{2i(\beta_{m',vis}h_m + \beta_{m',vis}h_m')} \exp[iz_3(k_{m',vis} \cos\theta_{m',vis}(-1-\tan\theta_{m',SF} \tan\theta_{m',vis}))]\} \\
& \times \{\exp[iz_3(k_{m',jr} \cos\theta_{m',jr}(1-\tan\theta_{m',SF} \tan\theta_{m',jr}))] \\
& + r_{m'2jr\beta} e^{2i(\beta_{m',ir}h_m + \beta_{m',ir}h_m')} \exp[iz_3(k_{m',jr} \cos\theta_{m',jr}(-1-\tan\theta_{m',SF} \tan\theta_{m',jr}))]\} \quad (3.36)
\end{aligned}$$