二層膜および三層膜からの和周波(SFG)光

目次

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。

$$r_{1m,s} = \frac{n_1\cos\theta_1 - n_m\cos\theta_m}{n_1\cos\theta_1 + n_m\cos\theta_m}, \qquad t_{1m,s} = \frac{2n_1\cos\theta_1}{n_1\cos\theta_1 + n_m\cos\theta_m}$$

$$r_{1m,p} = \frac{n_1\cos\theta_m - n_m\cos\theta_1}{n_1\cos\theta_m + n_m\cos\theta_1}, \qquad t_{1m,p} = \frac{2n_1\cos\theta_1}{n_1\cos\theta_m + n_m\cos\theta_1}$$

$r_{1m,x} = -r_{m1,x} = r_{1m,p}$, $\quad r_{1m,y} = -r_{m1,y} = r_{1m,s}$, $\quad r_{1m,z} = -r_{m1,z} = -r_{1m,p}$

$r_{2m,x} = -r_{m2,x} = r_{2m,p}$, $\quad r_{2m,y} = -r_{m2,y} = r_{2m,s}$, $\quad r_{2m,z} = -r_{m2,z} = -r_{2m,p}$

$t_{1m,x} = (\cos\theta_m/\cos\theta_1)t_{1m,p}$, $\quad t_{1m,y} = t_{1m,s}$, $\quad t_{1m,z} = (\sin\theta_m/\sin\theta_1)t_{1m,p}$

$t_{m1,x} = (\cos\theta_1/\cos\theta_m)t_{m1,p}$, $\quad t_{m1,y} = t_{m1,s}$, $\quad t_{m1,z} = (\sin\theta_1/\sin\theta_m)t_{m1,p}$

$t_{2m,x} = (\cos\theta_m/\cos\theta_2)t_{2m,p}$, $\quad t_{2m,y} = t_{2m,s}$, $\quad t_{2m,z} = (\sin\theta_m/\sin\theta_2)t_{2m,p}$

$t_{m2,x} = (\cos\theta_2/\cos\theta_m)t_{m2,p}$, $\quad t_{m2,y} = t_{m2,s}$, $\quad t_{m2,z} = (\sin\theta_2/\sin\theta_m)t_{m2,p}$

$t_{1m,\alpha}t_{m1,\alpha} = 1 + r_{1m,\alpha}r_{m1,\alpha} = 1 - r_{1m,\alpha}^2$, $\quad t_{2m,\alpha}t_{m2,\alpha} = 1 + r_{2m,\alpha}r_{m2,\alpha} = 1 - r_{2m,\alpha}^2$, $\quad (\alpha = x, y, z)$

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 $\boldsymbol{E}_{SF}$ 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 $4\pi i\omega_{SF}/c$（屈折率の代わりに波数ベクトルを使うときには $4\pi i\omega_{SF}^2/c^2$）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；$L_{i/j,s(p),\alpha}$**：** 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 (α = 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。

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

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。

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

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。

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

上に示した電場と分極の間の関係式は、SFG 分極と SFG 光に限定されるものでとはない。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

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

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

$$\times \exp[2ni(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \quad (2.1)$$

1/m' 界面の m' 側：

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

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

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

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

$$\times \exp[2ni(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \quad (2.2)$$

m/2 界面の 2 側：

(a): E^+ source

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

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

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

$$\times \exp[2ni(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \quad (2.3)$$

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

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

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

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

$$\times \exp[i(2n+1)(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \quad (2.4)$$

m/2 界面の m 側：

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

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

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

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

$$
\times \exp[i(2n+1)(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \tag{2.5}
$$

m'/m 界面の m' 側：

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

$$
E_{vis\alpha}(h_{m'}^{-})E_{ir,\beta}(h_{m'}^{-}) = E^0{}_{vis\alpha}E^0{}_{ir,\beta}
$$

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

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

$$
\times \exp[ih_{m'}\tan\theta_{m',SF}(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})]
$$

$$
\times \exp[i(2n+1)(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \tag{2.6}
$$

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

$$
E_{vis\alpha}(h_{m'}^{-})E_{ir,\beta}(h_{m'}^{-}) = E^0{}_{vis\alpha}E^0{}_{ir,\beta}
$$

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

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

$$
\times \exp[ih_{m'}\tan\theta_{m',SF}(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})]
$$

$$
\times \exp[2ni(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \tag{2.7}
$$

m'/m 界面の m 側：

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

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

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

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

$$
\times \exp[ih_{m'}\tan\theta_{m',SF}(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})]
$$

$$
\times \exp[2ni(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \tag{2.8}
$$

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

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

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

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

$$\times \exp[ih_{m'}\tan\theta_{m',SF}(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})]$$

$$\times \exp[2ni(h_m\tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \qquad (2.9)$$

m' 層の深さ z_1 点

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

$$E_{vis\alpha}(z_1) = E^{0}{}_{vis\alpha}\frac{t_{1m',vis\alpha}}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}}$$

$$\times\{(1+r_{m'm,vis\alpha}r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m})\exp[iz_1k_{m',vis}\cos\theta_{m',vis}(1+\tan\theta_{m',SF}\tan\theta_{m',vis})]$$

$$+(r_{m'm,vis\alpha}+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m})e^{2i\beta_{m',vis}h_{m'}}\exp[iz_1k_{m',vis}\cos\theta_{m',vis}(-1+\tan\theta_{m',SF}\tan\theta_{m',vis})]\}$$

$$\times\exp[-i(2n+2)(h_m\tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})k_{m,vis}\sin\theta_{m,vis}] \qquad (2.10a)$$

$$E_{ir,\beta}(z_1) = E^{0}{}_{ir,\beta}\frac{t_{1m',ir,\beta}}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}}$$

$$\times\{(1+r_{m'm,ir,\beta}r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})\exp[iz_1k_{m',ir}\cos\theta_{m',ir}(1+\tan\theta_{m',SF}\tan\theta_{m',ir})]$$

$$+(r_{m'm,ir,\beta}+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})e^{2i\beta_{m',ir}h_{m'}}\exp[iz_1k_{m',ir}\cos\theta_{m',ir}(-1+\tan\theta_{m',SF}\tan\theta_{m',ir})]\}$$

$$\times\exp[-i(2n+2)(h_m\tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})k_{m,vis}\sin\theta_{m,vis}] \qquad (2.10b)$$

$$E_{vis\alpha}(z_1)E_{ir,\beta}(z_1) = E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}$$

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

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

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(-1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(-1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(-1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(-1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]\}$$

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

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

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

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

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

m 層の m'/m 界面から深さ z_2 の点

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

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

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

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

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

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

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

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

$$
\begin{aligned}
&E_{vis\alpha}(h_m+z_2)E_{ir,\beta}(h_m+z_2)=E^0{}_{vis\alpha}E^0{}_{ir,\beta} \\
&\quad\times\frac{t_{1m',vis\alpha}t_{m'm,vis\alpha}e^{i\beta_{m',vis}h_{m'}}}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}} \\
&\quad\times\frac{t_{1m',ir,\beta}t_{m'm,ir,\beta}e^{i\beta_{m',ir}h_{m'}}}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}} \\
&\quad\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(1-\tan\theta_{m,SF}\tan\theta_{m,ir}))] \\
&\quad+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m} \\
&\quad\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(-1-\tan\theta_{m,SF}\tan\theta_{m,ir}))] \\
&\quad+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m} \\
&\quad\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(-1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(1-\tan\theta_{m,SF}\tan\theta_{m,ir}))] \\
&\quad+r_{m2,vis\alpha}r_{m2,ir,\beta}e^{2i(\beta_{m,ir}+\beta_{m,vis})h_m} \\
&\quad\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(-1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(-1-\tan\theta_{m,SF}\tan\theta_{m,ir}))] \\
&\quad\times\exp[-i2n(h_m\tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF})(k_{m,vis}\sin\theta_{m,vis}+k_{m,ir}\sin\theta_{m,ir})]
\end{aligned}
\tag{2.17}
$$

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): $\boldsymbol{E^+}$ **(by reflection and transmission) sources and** $\boldsymbol{E^-}$ **(for** $\boldsymbol{n = 0}$**) source**

$$
\begin{aligned}
&P_a^*(0^-)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta} \\
&\quad\times\frac{(1+r_{1m',vis\alpha})[(1+r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}})+(r_{m'm,vis\alpha}+e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}]}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}} \\
&\quad\times\frac{(1+r_{1m',ir,\beta})[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})+(r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}]}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}}
\end{aligned}
\tag{2.18}
$$

1/m' 界面の m' 側：

(a): $\boldsymbol{E^+}$ **and** $\boldsymbol{E^-}$ **(by reflection) sources**

$$
\begin{aligned}
&P_a^*(0^+)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta} \\
&\quad\times\frac{t_{1m',vis\alpha}[(1+r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}})+(r_{m'm,vis\alpha}+e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}]}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}} \\
&\quad\times\frac{t_{1m',ir,\beta}[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})+(r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}]}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}}
\end{aligned}
\tag{2.19}
$$

m/2 界面の 2 側：

(a): $\boldsymbol{E^{+}}$ **source**

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

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

$$\times\frac{t_{1m',ir,\beta}\,t_{m'm,ir,\beta}\,t_{m2,ir,\beta}\,e^{i(\beta_{m',ir}h_{m'}+\beta_{m,ir}h_m)}}{1+r_{1m',ir,\beta}\,r_{m'm,ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}\,e^{2i\beta_{m,ir}h_m}} \tag{2.20}$$

(b): $\boldsymbol{E^{-}}$ **sources (for** $\boldsymbol{n>0}$**, by reflection)**

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

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

$$\times\frac{t_{1m',ir,\beta}\,t_{m'm,ir,\beta}\,t_{m2,ir,\beta}\,e^{i(\beta_{m',ir}h_{m'}+\beta_{m,ir}h_m)}}{1+r_{1m',ir,\beta}\,r_{m'm,ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}\,e^{2i\beta_{m,ir}h_m}} \tag{2.21}$$

m/2 界面の m 側：

(a): $\boldsymbol{E^{+}}$ **(by reflection) and** $\boldsymbol{E^{-}}$ **sources**

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

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

$$\times\frac{t_{1m',ir,\beta}\,t_{m'm,ir,\beta}\,(1+r_{m2,ir,\beta})e^{i(\beta_{m',ir}h_{m'}+\beta_{m,ir}h_m)}}{1+r_{1m',ir,\beta}\,r_{m'm,ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}\,e^{2i\beta_{m,ir}h_m}} \tag{2.22}$$

m'/m 界面の m' 側：

(a): $\boldsymbol{E^{+}}$ **and** $\boldsymbol{E^{-}}$ **(by reflection) sources**

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

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

$$\times\frac{t_{1m',ir,\beta}\,e^{i\beta_{m',ir}h_{m'}}(1+r_{m'm,ir,\beta})(1+r_{m2,ir,\beta}\,e^{2i\beta_{m,ir}h_m})}{1+r_{1m',ir,\beta}\,r_{m'm,ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}\,e^{2i\beta_{m,ir}h_m}} \tag{2.23}$$

(b): $\boldsymbol{E^{+}}$ **(by reflection) and** $\boldsymbol{E^{-}}$ **sources**

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

$$\times\frac{t_{1m',vis,\alpha}e^{i\beta_{m',vis}h_{m'}}(1+r_{m'm,vis,\alpha})(1+r_{m2,vis,\alpha}e^{2i\beta_{m,vis}h_m})}{1+r_{1m',vis,\alpha}r_{m'm,vis,\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis,\alpha}+r_{1m',vis,\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis,\alpha}e^{2i\beta_{m,vis}h_m}}$$
$$\times\frac{t_{1m',ir,\beta}e^{i\beta_{m',ir}h_{m'}}(1+r_{m'm,ir,\beta})(1+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}} \qquad (2.24)$$

m'/m 界面の m 側：

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

$$P_a^*(h_m^+)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$
$$\times\frac{t_{1m',vis\alpha}t_{m'm,vis\alpha}e^{i\beta_{m',vis}h_{m'}}(1+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m})}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}}$$
$$\times\frac{t_{1m',ir,\beta}e^{i\beta_{m',ir}h_{m'}}(1+r_{m'm,ir,\beta})(1+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}} \qquad (2.25)$$

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

$$P_a^*(h_m^+)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$
$$\times\frac{t_{1m',vis\alpha}t_{m'm,vis\alpha}e^{i\beta_{m',vis}h_{m'}}(1+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m})}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}}$$
$$\times\frac{t_{1m',ir,\beta}t_{m'm,ir,\beta}e^{i\beta_{m',ir}h_{m'}}(1+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}} \qquad (2.26)$$

m' 層の深さ z_1 点：

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

$$P_a^*(z_1)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$
$$\times\frac{t_{1m',vis\alpha}}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}}$$
$$\times\frac{t_{1m',ir,\beta}}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}}$$
$$\times\{(1+r_{m'm,vis\alpha}r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m})(1+r_{m'm,ir,\beta}r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})$$
$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$
$$+(1+r_{m'm,vis\alpha}r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m})(r_{m'm,ir,\beta}+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})e^{2i\beta_{m',ir}h_{m'}}$$
$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(-1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$
$$+(r_{m'm,vis\alpha}+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m})(1+r_{m'm,ir,\beta}r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m})e^{2i\beta_{m',vis}h_{m'}}$$
$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(-1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(-1+\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(-1+\tan\theta_{m',SF}\tan\theta_{m',ir}))]\} \tag{2.27}$$

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

$$P_a^*(z_1)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$

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

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

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(1-\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(1-\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(1-\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(-1-\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(-1-\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(1-\tan\theta_{m',SF}\tan\theta_{m',ir}))]$$

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

$$\times\exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(-1-\tan\theta_{m',SF}\tan\theta_{m',vis})+k_{m',ir}\cos\theta_{m',ir}(-1-\tan\theta_{m',SF}\tan\theta_{m',ir}))]\} \tag{2.28}$$

m 層 の m'/m 界面から深さ z_2 の点：

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

$$P_a^*(z_2)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$

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

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

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(1+\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(1+\tan\theta_{m,SF}\tan\theta_{m,ir}))]$$

$$+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}$$

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(1+\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(-1+\tan\theta_{m,SF}\tan\theta_{m,ir}))]$$

$$+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}$$

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(-1+\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(1+\tan\theta_{m,SF}\tan\theta_{m,ir}))]$$

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

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(-1+\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(-1+\tan\theta_{m,SF}\tan\theta_{m,ir}))]$$

(2.29)

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

$$P_a^*(z_2)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$

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

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

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(1-\tan\theta_{m,SF}\tan\theta_{m,ir}))]$$

$$+r_{m2,ir,\beta}\,e^{2i\beta_{m,ir}h_m}$$

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(-1-\tan\theta_{m,SF}\tan\theta_{m,ir}))]$$

$$+r_{m2,vis\alpha}\,e^{2i\beta_{m,vis}h_m}$$

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(-1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(1-\tan\theta_{m,SF}\tan\theta_{m,ir}))]$$

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

$$\times\{\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(-1-\tan\theta_{m,SF}\tan\theta_{m,vis})+k_{m,ir}\cos\theta_{m,ir}(-1-\tan\theta_{m,SF}\tan\theta_{m,ir}))]\quad(2.30)$$

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 $t_{1m'}L^+{}_{1/1}P(z_1=0)$ 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。

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

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

ここで、

$$(L^-{}_{1/1,px}+r_{1m',p}L^+{}_{1/1,px})=(r_{1m',p}L^-{}_{1/1,px}+L^+{}_{1/1,px})=L^-{}_{1/m',px}$$

$$(L^-{}_{1/1,sy}+r_{1m',s}L^+{}_{1/1,sy})=(r_{1m',s}L^-{}_{1/1,sy}+L^+{}_{1/1,sy})=L^-{}_{1/m',sy}$$

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

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、

$$E^{-}{}_{1}(0^{-})_{net,p} = \sum_{\alpha,\beta} E^{0}{}_{vis\alpha} E^{0}{}_{ir,\beta}$$
$$\times \frac{(1+r_{1m',vis\alpha})[(1+r_{m'm,vis\alpha}e^{2i\beta_{m';vis}h_{m'}}) + (r_{m'm,vis\alpha}+e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}]}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}}$$
$$\times \frac{(1+r_{1m',ir,\beta})[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}) + (r_{m'm,ir,\beta}+e^{2i\beta_{m';ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}]}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m';ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m';ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}}$$
$$\times[\frac{(1+r_{m'm,SF,p}r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}) + (r_{m'm,SF,p}+r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}})e^{2i\beta_{m';SF}h_{m'}}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m';SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}} L^{-}{}_{1/m',px}\chi_{x\alpha\beta}$$
$$+\frac{(1+r_{m'm,SF,p}r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}) - (r_{m'm,SF,p}+r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}})e^{2i\beta_{m',SF}h_{m'}}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m';SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}} L^{-}{}_{1/m',pz}\chi_{z\alpha\beta}] \quad (n_{m''}=n_{1})$$

(2.31a)

$$E^{-}{}_{1}(0^{-})_{net,s} = \sum_{\alpha,\beta} E^{0}{}_{vis\alpha} E^{0}{}_{ir,\beta}$$
$$\times \frac{(1+r_{1m',vis\alpha})[(1+r_{m'm,vis\alpha}e^{2i\beta_{m';vis}h_{m'}}) + (r_{m'm,vis\alpha}+e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}]}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}}$$
$$\times \frac{(1+r_{1m',ir,\beta})[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}) + (r_{m'm,ir,\beta}+e^{2i\beta_{m';ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}]}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m';ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m';ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}}$$
$$\times \frac{(1+r_{m'm,SF,s}r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}}) + (r_{m'm,SF,s}+r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}})e^{2i\beta_{m',SF}h_{m'}}}{1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m';SF}h_{m'}})r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}}} L^{-}{}_{1/m',sy}\chi_{y\alpha\beta} \quad (2.31b)$$

(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、

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

(2.18) 式により、

$$E^{+}{}_{2}(h_m{}^{+})_{net,p} = \sum_{\alpha,\beta} E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}$$
$$\times \frac{(1+r_{1m',vis\alpha})[(1+r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}})+(r_{m'm,vis\alpha}+e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}]}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}}$$
$$\times \frac{(1+r_{1m',ir,\beta})[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})+(r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}]}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}}$$
$$\times \frac{t_{1m',SF,p}t_{m2,SF,p}e^{i(\beta_{m,SF}h_m+\beta_{m',SF}h_{m'})}(L^{+}{}_{1/m',px}\chi_{x\alpha\beta}+L^{+}{}_{1/m',pz}\chi_{z\alpha\beta})}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_m}} \quad (n_{m''}=n_1) \qquad (2.32a)$$

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

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。**

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

ここで、

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

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

$t_{1m',p}L^{+}{}_{m'/m',pz} = -t_{1m',p}L^{-}{}_{m'/m',pz} = L^{-}{}_{1/m',pz}$ $(n_{m''} = n_{m'})$

であるから、

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

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

(2.19) **式により、**

$$E^{-}{}_{1}(0^{-})_{net,p}=\sum_{\alpha,\beta}E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}$$
$$\times\frac{t_{1m',vis\alpha}[(1+r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}})+(r_{m'm,vis\alpha}+e^{2i\beta_{m';vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}]}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m';vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m';vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}}$$
$$\times\frac{t_{1m',ir,\beta}[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})+(r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}]}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m';ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}}$$
$$\times[\frac{(1+r_{m'm,SF,p}r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}})+(r_{m'm,SF,p}+r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}})e^{2i\beta_{m',SF}h_{m'}}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m';SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}}L^{-}{}_{1/m',px}\chi_{x\alpha\beta}$$
$$+\frac{(1+r_{m'm,SF,p}r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}})-(r_{m'm,SF,p}+r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}})e^{2i\beta_{m',SF}h_{m'}}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m';SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}}L^{-}{}_{1/m',pz}\chi_{z\alpha\beta}]\quad(n_{m''}=n_{m'})$$

(2.33a)

$$E^{-}{}_{1}(0^{-})_{net,s}=\sum_{\alpha,\beta}E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}$$
$$\times\frac{t_{1m',vis\alpha}[(1+r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}})+(r_{m'm,vis\alpha}+e^{2i\beta_{m';vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}]}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m';vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m';vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}}$$
$$\times\frac{t_{1m',ir,\beta}[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})+(r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}]}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m';ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}}$$
$$\times\frac{(1+r_{m'm,SF,s}r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}})+(r_{m'm,SF,s}+r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}})e^{2i\beta_{m',SF}h_{m'}}}{1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m';SF}h_{m'}})r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}}}L^{-}{}_{1/m',sy}\chi_{y\alpha\beta}\qquad(2.33b)$$

(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。**

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

ここで、

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

であるから、

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

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

(2.19) **式により、**

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

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

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

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

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

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

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

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

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。**

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

ここで、

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

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

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

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、**

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

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

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

$$\times \frac{t_{2m,SF,p} t_{m'1,SF,p} e^{2i\beta_{m,SF} h_m} (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) [L^-{}_{m/2,px} \chi_{x\alpha\beta} + L^-{}_{m/2,pz} \chi_{z\alpha\beta}]}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}} \quad (n_{m''} = n_2) \quad (2.35a)$$

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

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

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

$$\times \frac{t_{2m,SF,s} t_{m'1,SF,s} (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m',SF} h_{m'}}) e^{2i\beta_{m,SF} h_m} L^-{}_{m/2,sy} \chi_{y\alpha\beta}}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF} h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF} h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF} h_m}} \quad (2.35b)$$

(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** $L^-{}_{m/m} P(z_2)$ **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。**

$$E^+{}_2(h_{m'} + h_m{}^+)_{net} = \{L^+{}_{2/2} + L^-{}_{2/2}[r_{2m} - \frac{t_{2m} t_{m2} b^2 (r_{m'm} + r_{1m'} a^2)}{1 + r_{1m'} r_{m'm} a^2 + (r_{m'm} + r_{1m'} a^2) r_{m2} b^2}]\} P^* (z_2 = h_m{}^+)$$

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

ここで、

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

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

$$(L^+{}_{2/2,pz} + r_{2m,p} L^-{}_{2/2,pz}) = -(r_{m2,p} L^+{}_{2/2,pz} + L^-{}_{2/2,pz}) = L^+{}_{2/m,pz} \quad (n_{m''} = n_2)$$

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、**

$$\begin{aligned}E^{+}{}_{2,p}(h_{m'}+h_{m}{}^{+})_{net}&=\sum_{\alpha,\beta}E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}\\&\times\frac{t_{1m',vis\alpha}t_{m'm,vis\alpha}t_{m2,vis\alpha}e^{i(\beta_{m',vis}h_{m'}+\beta_{m,vis}h_{m})}}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}}\\&\times\frac{t_{1m',ir,\beta}t_{m'm,ir,\beta}t_{m2,ir,\beta}e^{i(\beta_{m',ir}h_{m'}+\beta_{m,ir}h_{m})}}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}}\\&\times\left\{\frac{[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})e^{2i\beta_{m,SF}h_{m}}]L^{-}{}_{2/m,px}\chi_{x\alpha\beta}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}}\right.\\&\left.+\frac{[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})-(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})e^{2i\beta_{m,SF}h_{m}}]L^{-}{}_{2/m,pz}\chi_{z\alpha\beta}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}}\right\}\quad(n_{m''}=n_{2})\end{aligned}$$

(2.36a)

$$\begin{aligned}E^{+}{}_{2,s}(h_{m'}+h_{m}{}^{+})_{net}&=\sum_{\alpha,\beta}E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}\\&\times\frac{t_{1m',vis\alpha}t_{m'm,vis\alpha}t_{m2,vis\alpha}e^{i(\beta_{m',vis}h_{m'}+\beta_{m,vis}h_{m})}}{1+r_{1m',vis\alpha}r_{m'm,vis\alpha}e^{2i\beta_{m',vis}h_{m'}}+(r_{m'm,vis\alpha}+r_{1m',vis\alpha}e^{2i\beta_{m',vis}h_{m'}})r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_{m}}}\\&\times\frac{t_{1m',ir,\beta}t_{m'm,ir,\beta}t_{m2,ir,\beta}e^{i(\beta_{m',ir}h_{m'}+\beta_{m,ir}h_{m})}}{1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}}+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_{m}}}\\&\times\frac{[(1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}})+(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m',SF}h_{m'}})e^{2i\beta_{m,SF}h_{m}}]L^{-}{}_{2/m,sy}\chi_{y\alpha\beta}}{1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}}}\end{aligned}\qquad(2.36b)$$

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、

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

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

(2.23) 式を参照して、

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

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

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

$$\times \frac{e^{i(\beta_{m',SF}h_{m'} + \beta_{m,SF}h_{m})} [(1 + r_{m2,SF,p}) L^{-}{}_{m'/m,px} \chi_{x\alpha\beta} + (1 - r_{m2,SF,p}) L^{-}{}_{m'/m,pz} \chi_{z\alpha\beta}]}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF}h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF}h_{m}}} \qquad (n_{m''} = n_{m}) \qquad (2.37a)$$

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

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

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

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

(b): 透過方向

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

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

ここで、

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

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

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

であるから、

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

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

(2.23) **式を参照して、**

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

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

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

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

$$+\frac{[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})e^{2i\beta_{m,SF}h_{m}}]L^{+}{}_{m/2,pz}\chi_{z\alpha\beta}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_{m}}}\}\quad(n_{m''}=n_{m})$$

(2.38a)

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

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

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

$$\times\frac{[(1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}})-(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m',SF}h_{m'}})e^{2i\beta_{m,SF}h_{m}}]L^{+}{}_{m/2,sy}\chi_{y\alpha\beta}}{1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}}}\quad(2.38b)$$

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。**

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

ここで、

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

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

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

であるから、

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

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

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

(2.23) **式を参照して、**

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

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

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

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

$$+ \frac{e^{i\beta_{m',SF}h_{m'}}[(1-r_{mm',SF,p})(1-r_{m2,SF,p}e^{2i\beta_{m,SF}h_m})]L^-{}_{1/m',pz}\chi_{z\alpha\beta}}{1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_m}} \} \quad (n_{m''}=n_{m'}) \tag{2.39a}$$

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

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

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

$$\times \frac{e^{i\beta_{m',SF}h_{m'}}(1+r_{mm',SF,s})(1+r_{m2,SF,s}e^{2i\beta_{m,SF}h_m})L^-{}_{1/m',sy}\chi_{y\alpha\beta}}{1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,p}e^{2i\beta_{m,SF}h_m}} \tag{2.39b}$$

(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。**

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

ここで、

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

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

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

であるから、

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

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

(2.23) 式を参照して、

$$\begin{aligned} E^{+}{}_{2,p}(h_{m'} + h_{m}{}^{+})_{net} &= \sum_{\alpha,\beta} E^{0}{}_{vis\alpha} E^{0}{}_{ir,\beta} \\ &\times \frac{t_{1m',vis\alpha} e^{i\beta_{m';vis}h_{m'}} (1 + r_{m'm,vis\alpha})(1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_{m}})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m';vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m';vis}h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_{m}}} \\ &\times \frac{t_{1m',ir,\beta} e^{i\beta_{m',ir}h_{m'}} (1 + r_{m'm,ir,\beta})(1 + r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_{m}})}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m';ir}h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_{m}}} \\ &\times \frac{t_{m2,SF,p} e^{i\beta_{m;SF}h_{m'}} [(1 + r_{m'1,SF,p} e^{2i\beta_{m;SF}h_{m'}}) L^{+}{}_{m'/m,px} \chi_{x\alpha\beta} + (1 - r_{m'1,SF,p} e^{2i\beta_{m',SF}h_{m'}}) L^{+}{}_{m'/m,zx} \chi_{z\alpha\beta}]}{1 + r_{1m',SF,p} r_{m'm,SF,p} e^{2i\beta_{m',SF}h_{m'}} + (r_{m'm,SF,p} + r_{1m',SF,p} e^{2i\beta_{m',SF}h_{m'}}) r_{m2,SF,p} e^{2i\beta_{m,SF}h_{m}}} \quad (n_{\mathrm{m''}} = n_{\mathrm{m'}}) \end{aligned} \tag{2.40a}$$

$$\begin{aligned} E^{+}{}_{2,s}(h_{m'} + h_{m}{}^{+})_{net} &= \sum_{\alpha,\beta} E^{0}{}_{vis\alpha} E^{0}{}_{ir,\beta} \\ &\times \frac{t_{1m',vis\alpha} e^{i\beta_{m';vis}h_{m'}} (1 + r_{m'm,vis\alpha})(1 + r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_{m}})}{1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m';vis}h_{m'}} + (r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m';vis}h_{m'}}) r_{m2,vis\alpha} e^{2i\beta_{m,vis}h_{m}}} \\ &\times \frac{t_{1m',ir,\beta} e^{i\beta_{m',ir}h_{m'}} (1 + r_{m'm,ir,\beta})(1 + r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_{m}})}{1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir}h_{m'}} + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m';ir}h_{m'}}) r_{m2,ir,\beta} e^{2i\beta_{m,ir}h_{m}}} \\ &\times \frac{t_{m2,SF,s} e^{i\beta_{m;SF}h_{m'}} (1 + r_{m'1,SF,s} e^{2i\beta_{m;SF}h_{m'}}) L^{+}{}_{m'/m,sy} \chi_{y\alpha\beta}}{1 + r_{1m',SF,s} r_{m'm,SF,s} e^{2i\beta_{m',SF}h_{m'}} + (r_{m'm,SF,s} + r_{1m',SF,s} e^{2i\beta_{m';SF}h_{m'}}) r_{m2,SF,s} e^{2i\beta_{m,SF}h_{m}}} \end{aligned} \tag{2.40b}$$

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。**

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

ここで、

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

であるから、

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

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

(2.25) 式を参照して、

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

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

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

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

(2.41a)

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

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

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

$$\times\frac{t_{m'1,SF,s}e^{i\beta_{m',SF}h_{m'}}(1+r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}})L^{-}{}_{m'/m,sy}\chi_{y\alpha\beta}}{1+r_{1m',SF,s}r_{m'm,SF,s}e^{2i\beta_{m',SF}h_{m'}}+(r_{m'm,SF,s}+r_{1m',SF,s}e^{2i\beta_{m',SF}h_{m'}})r_{m2,SF,s}e^{2i\beta_{m,SF}h_{m}}}\qquad(2.41b)$$

(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。**

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

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、

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

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

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

(2.25) **式を参照して、**

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

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

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

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

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

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

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

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

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

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。**

$$
a_0 = e^{ik_{m'} z_1 / \cos\theta_{m'}}, \qquad a_0{}^* = e^{i\beta_{m'} h_{m'} / \cos\theta_{m'}} e^{-ik_{m'} z_1 / \cos\theta_{m'}}
$$

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** $a_0 = e^{i\beta_{m'} z_1}$, $a_0{}^* = e^{i\beta_{m'} h_{m'}} e^{-i\beta_{m'} z_1}$ **とする。また、上で行ったと同様に下のように置く。**

$$P_a^* = \sum_{\alpha,\beta} \chi_{a\alpha\beta} E^0{}_{vis\alpha} E^0{}_{ir,\beta}$$

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

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

(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。**

$$E^-{}_1(0^-) = \sum_{\alpha\beta} t_{m'1} e^{2i\beta_{m'}h_{m'}} (r_{m'm} + r_{m2} e^{2i\beta_m h_m}) L^+{}_{m'/m'} P_a^*$$

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

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

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

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

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。**

$$E^-{}_1(0^-) = \sum_{\alpha\beta} t_{m'1} (1 + r_{mm'} r_{m2} e^{2i\beta_m h_m}) L^-{}_{m'/m'} P_a^*$$

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

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

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

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

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**（$z_1 = 0 \to h_{m'}$）**、**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**（$z_1 = h_{m'} \to 0$）**積分し、さらに関係式**

$$t_{m'1,p} L^+{}_{m'/m',px} = L^-{}_{1/m',px}, \quad t_{m'1,s} L^+{}_{m'/m',sy} = L^-{}_{1/m',sy}, \quad t_{m'1,p} L^+{}_{m'/m',pz} = -L^-{}_{1/m',pz} \quad (n_{m''} = n_{m'})$$

$$t_{m'1,p} L^-{}_{m'/m',px} = L^-{}_{1/m',px}, \quad t_{m'1,s} L^-{}_{m'/m',sy} = L^-{}_{1/m',sy}, \quad t_{m'1,p} L^-{}_{m'/m',pz} = L^-{}_{1/m',pz} \quad (n_{m''} = n_{m'})$$

を考慮して整理すると、下式が得られる。

$$E^{-}{}_{1}(0^{-})_{net} = \sum_{\alpha\beta} L^{-}{}_{1/m'} P_a{}^{*} \frac{i}{\delta}$$

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

$$\times[(1+r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir}}$$

$$\pm(r_{m'm,SF}+r_{m2,SF} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir}}]$$

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

$$\times[(1+r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir}}$$

$$\pm(r_{m'm,SF}+r_{m2,SF} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir}}]$$

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

$$\times[(1+r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir}}$$

$$\pm(r_{m'm,SF}+r_{m2,SF} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir}}]$$

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

$$\times[(1+r_{mm',SF} r_{m2,SF} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir}}$$

$$\pm(r_{m'm,SF}+r_{m2,SF} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}}]\frac{e^{i(-\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir}}\}$$

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

よって、

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

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

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

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

$$\times[(1+r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir}}$$

$$+(r_{m'm,SF,p}+r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir}}]$$

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

$$\times[(1+ r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir}}$$

$$+(r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir}}]$$

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

$$\times[(1+ r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir}}$$

$$+(r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir}}]$$

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

$$\times[(1+ r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir}}$$

$$+(r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir}}]\} L^{-}_{1/m',px} \chi_{x\alpha\beta}$$

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

$$+[(1 + r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir}}$$

$$-(r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir}}]$$

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

$$+[(1 + r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir}}$$

$$-(r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m} e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir}}]$$

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

$$+[(1 + r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir}}$$

$$-(r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}-\beta_{m',vis}+\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}-\beta_{m',ir}}]$$

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

$$+[(1 + r_{mm',SF,p} r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) \frac{e^{i(\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir}}$$

$$-(r_{m'm,SF,p} + r_{m2,SF,p} e^{2i\beta_{m,SF}h_m}) e^{2i\beta_{m',SF}h_{m'}} \frac{e^{i(-\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir}}]\} L^{-}_{1/m',pz} \chi_{z\alpha\beta} \} \quad (n_{m''} = n_{m'}) \qquad (2.43a)$$

$$
\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'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 [(1+r_{mm',SF,s} r_{m2,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}} \\
& \quad +(r_{m'm,SF,s} + r_{m2,SF,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}}] \\
& +(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 [(1+r_{mm',SF,s} r_{m2,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}} \\
& \quad +(r_{m'm,SF,s} + r_{m2,SF,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}}] \\
& +(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 [(1+r_{mm',SF,s} r_{m2,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}} \\
& \quad +(r_{m'm,SF,s} + r_{m2,SF,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}}] \\
& +(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 [(1+r_{mm',SF,s} r_{m2,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}} \\
& \quad +(r_{m'm,SF,s} + r_{m2,SF,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}
\end{aligned}
\tag{2.43b}
$$

(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。**

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

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

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

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。**

$$E^+{}_2(h_{m'}+h_m{}^+)=\sum_{\alpha\beta}t_{m2}e^{i\beta_{m'}h_{m'}}r_{m'1}t_{m'm}L^-{}_{m'/m'}P_a{}^*$$

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

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

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

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

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**（$z_1=0\to h_{m'}$）**、**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**（$z_1=h_{m'}\to 0$）**積分し、さらに関係式**

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

を考慮して整理すると、下式が得られる。

$$E^+{}_2(h_{m'}+h_m{}^+)=\sum_{\alpha\beta}t_{m2}e^{i(\beta_{m'}h_{m'}+\beta_m h_m)}L^+{}_{m'/m}P_a{}^*\frac{i}{\delta}$$

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

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

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

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

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

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

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

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

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

よって、

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\times\left[\frac{e^{i(-\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir}}+r_{m'1,SF,s}\frac{e^{i(\beta_{m;SF}-\beta_{m;vis}-\beta_{m',ir})h_{m'}}-1}{\beta_{m',SF}-\beta_{m',vis}-\beta_{m',ir}}\right]\}L^{+}{}_{m'/m,sy}\chi_{y\alpha\beta} \qquad (2.44b)$$

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。**

$$b_0=e^{ik_m z_2/\cos\theta_m},\qquad b_0{}^*=e^{i\beta_m h_m/\cos\theta_m}e^{-ik_m z_2/\cos\theta_m}$$

$$P_a{}^{*}=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}$$

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

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

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。**

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

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。**

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

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**

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

を考慮して整理すると、下式を得る。

$$E^{-}{}_{1}(0^{-}) = \sum_{\alpha\beta} t_{m'1} e^{i\beta_{m'} h_{m'}} L^{-}{}_{m'/m} P_a^{\,*} \frac{i}{\delta}$$
$$\times\{[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}} \pm r_{m2} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}}]$$
$$+ r_{m2,ir,\beta} e^{2i\beta_{m,ir} h_m}[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m} - 1}{\beta_{m,SF} + \beta_{m,vis}\beta_{m,ir}} \pm r_{m2} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}}]$$
$$+ r_{m2,vis\alpha} e^{2i\beta_{m,vis} h_m}[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} + \beta_{m,ir}} \pm r_{m2} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} - \beta_{m,ir}}]$$
$$+ r_{m2,vis\alpha} r_{m2,ir,\beta} e^{2i(\beta_{m,vis}+\beta_{m,ir})h_m}[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m} - 1}{\beta_{m,SF} - \beta_{m,vis} - \beta_{m,ir}} \pm r_{m2} e^{2i\beta_{m,SF} h_m} \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}-w\beta_{m,ir})h_m} - 1}{\beta_{m,SF} + \beta_{m,vis} + \beta_{m,ir}}]\}$$

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

よって、

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

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

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

$$\times\{\{[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}} + r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}]$$

$$+r_{m2,ir,\beta}\, e^{2i\beta_{m,ir}h_m}[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}\beta_{m,ir}} + r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}]$$

$$+r_{m2,vis\alpha}\, e^{2i\beta_{m,vis}h_m}[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}} + r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}]$$

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

$$\times[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}} + r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}-w\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}}]\}L^{-}_{m'/m,px}\chi_{x\alpha\beta}$$

$$\times\{\{[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}} - r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}]$$

$$+r_{m2,ir,\beta}\, e^{2i\beta_{m,ir}h_m}[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}\beta_{m,ir}} - r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}]$$

$$+r_{m2,vis\alpha}\, e^{2i\beta_{m,vis}h_m}[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}} - r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}]$$

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

$$\times[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}} - r_{m2,SF,p}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}-w\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}}]\}L^{-}_{m'/m,pz}\chi_{z\alpha\beta} \quad (n_{m''}=n_m)$$

(2.45a)

$$E^{-}{}_1(0^-)_s = \sum_{\alpha\beta} E^0{}_{vis\alpha}\, E^0{}_{ir,\beta}\, t_{m'1,SF,s}\, e^{i(\beta_{m',SF}+\beta_{m',vis}+\beta_{m',ir})h_{m'}}\, \frac{i}{\delta}$$

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

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

$$\times\{[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}} + r_{m2,SF,s}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}]$$

$$+r_{m2,ir,\beta}\, e^{2i\beta_{m,ir}h_m}[\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}\beta_{m,ir}} + r_{m2,SF,s}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}]$$

$$+r_{m2,vis\alpha}\, e^{2i\beta_{m,vis}h_m}[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}} + r_{m2,SF,s}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}]$$

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

$$\times[\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}} + r_{m2,SF,s}\, e^{2i\beta_{m,SF}h_m}\, \frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}-w\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}}]\}L^{-}_{m'/m,sy}\chi_{y\alpha\beta} \qquad (2.45b)$$

(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。**

$$E^+{}_2(h_{m'}+h_m{}^+)=\sum_{\alpha\beta}t_{m2}e^{i\beta_m h_m}(1+r_{1m'}r_{m'm}e^{2i\beta_{m'}h_{m'}})L^+{}_{m/m}P_a{}^*$$
$$\times\{\exp[iz_2(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})]+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}\exp[iz_2(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})]$$
$$+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}\exp[iz_2(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})]$$
$$+r_{m2,vis\alpha}r_{m2,ir,\beta}e^{2i(\beta_{m,ir}+\beta_{m,vis})h_m}\exp[iz_2(-\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})]\}$$

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。**

$$E^+{}_2(h_{m'}+h_m{}^+)=-\sum_{\alpha\beta}t_{m2}e^{i\beta_m h_m}(r_{m'm}+r_{1m'}e^{2i\beta_{m'}h_{m'}})L^-{}_{m/m}P_a{}^*$$
$$\times\{\exp[iz_2(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})]+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}\exp[iz_2(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})]$$
$$+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}\exp[iz_2(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})]$$
$$+r_{m2,vis\alpha}r_{m2,ir,\beta}e^{2i(\beta_{m,ir}+\beta_{m,vis})h_m}\exp[iz_2(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})]\}$$

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**

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

を考慮して整理すると、下式を得る。

$$E^+{}_2(h_{m'}+h_m{}^+)=\sum_{\alpha\beta}e^{i\beta_m h_m}L^+{}_{m/2}P_a{}^*\frac{i}{\delta}$$
$$\times\{[(1+r_{1m',SF}r_{m'm,SF}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}$$
$$\mp(r_{m'm,SF}+r_{1m',SF}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}}]$$
$$+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}[(1+r_{1m',SF}r_{m'm,SF}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}$$
$$\mp(r_{m'm,SF}+r_{1m',SF}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}]$$
$$+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}[(1+r_{1m',SF}r_{m'm,SF}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}$$

$$
\mp(r_{m'm,SF}+r_{1m',SF}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}]
$$

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

$$
\mp(r_{m'm,SF}+r_{1m',SF}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}]\}
$$

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

よって、

$$
E^{+}{}_{2,p}(h_{m'}+h_m{}^{+})=\sum_{\alpha\beta}E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}e^{i(\beta_{m',vis}+\beta_{m',ir})h_{m'}}e^{i\beta_{m,SF}h_m}(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})
$$

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

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

$$
\times\{\{[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}
$$

$$
+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}}]
$$

$$
+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}
$$

$$
+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}]
$$

$$
+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}
$$

$$
+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}]
$$

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

$$
+(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}]\}L^{+}{}_{m/2,px}\chi_{x\alpha\beta}
$$

$$
+\{[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}
$$

$$
-(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}}]
$$

$$
+r_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}
$$

$$
-(r_{m'm,SF,p}+r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}]
$$

$$
+r_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}-\beta_{m,ir}}
$$

$$
\begin{aligned}
&-(r_{m'm,SF,p} + r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}+\beta_{m,ir}}]\\
&+r_{m2,vis\alpha}\,r_{m2,ir,\beta}\,e^{2i(\beta_{m',is}+\beta_{m,ir})h_m}[(1+r_{1m',SF,p}r_{m'm,SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(-\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}+\beta_{m,vis}+\beta_{m,ir}}\\
&-(r_{m'm,SF,p} + r_{1m',SF,p}e^{2i\beta_{m',SF}h_{m'}})\frac{e^{i(\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir})h_m}-1}{\beta_{m,SF}-\beta_{m,vis}-\beta_{m,ir}}]\}L^{+}{}_{m/2,pz}\chi_{z\alpha\beta}\}\quad (n_{\mathrm{m''}}=n_{\mathrm{m}})
\end{aligned}
\qquad (2.46a)
$$

$$
\begin{aligned}
E^{+}{}_{2,s}(h_{m'}+h_m{}^{+}) &= \sum_{\alpha\beta} E^{0}{}_{vis\,\alpha}E^{0}{}_{ir,\beta}\,e^{i(\beta_{m',vis}+\beta_{m',ir})h_{m'}}e^{i\beta_{m,SF}h_m}(1+r_{1m',SF,s}r_{m'm,SF,s}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,s}r_{m'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}}\\
&\quad+(r_{m'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_{m2,ir,\beta}e^{2i\beta_{m,ir}h_m}[(1+r_{1m',SF,s}r_{m'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}}\\
&\quad+(r_{m'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_{m2,vis\alpha}e^{2i\beta_{m,vis}h_m}[(1+r_{1m',SF,s}r_{m'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}}\\
&\quad+(r_{m'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_{m2,vis\alpha}\,r_{m2,ir,\beta}\,e^{2i(\beta_{m',is}+\beta_{m,ir})h_m}[(1+r_{1m',SF,s}r_{m'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}}\\
&\quad+(r_{m'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,sy}\chi_{y\alpha\beta}
\end{aligned}
\qquad (2.46b)
$$

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

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

$$\times \frac{\begin{array}{l}\{(1 + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}})[(1 + r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}})(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m'',vis} h_{m''}}) \\ +(r_{m'm,vis\alpha} + e^{2i\beta_{m',vis} h_{m'}})(r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m'',vis} h_{m''}})e^{2i\beta_{m,vis} h_m}]\}\end{array}}{\begin{array}{l}\{(1 + r_{1m',vis\alpha} r_{m'm,vis\alpha} e^{2i\beta_{m',vis} h_{m'}})(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m'',vis} h_{m''}}) \\ +(r_{m'm,vis\alpha} + r_{1m',vis\alpha} e^{2i\beta_{m',vis} h_{m'}})(r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m'',vis} h_{m''}})e^{2i\beta_{m,vis} h_m}\}\end{array}}$$

$$\times \frac{\begin{array}{l}\{(1 + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}})[(1 + r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) \\ +(r_{m'm,ir,\beta} + e^{2i\beta_{m',ir} h_{m'}})(r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}})e^{2i\beta_{m,ir} h_m}]\}\end{array}}{\begin{array}{l}\{(1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) \\ +(r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}})e^{2i\beta_{m,ir} h_m}\}\end{array}}$$

$$\times \exp[i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \qquad (3.1)$$

1/m' 界面の m' 側：

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

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

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

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

$$\times \exp[i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \qquad (3.2)$$

m''/2 界面の 2 側：

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

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

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

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

$$
\times \exp[i(2n+1)(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF}+h_{m''}\tan\theta_{m'',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \tag{3.3}
$$

m''/2 界面の m'' 側：

E^{+} **(by reflection and transmission) and *E***$^{-}$ **sources**

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

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

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

$$
\times \exp[i(2n+1)(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF}+h_{m''}\tan\theta_{m'',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})] \tag{3.4}
$$

m'/m 界面の m' 側：

E^{+} **and *E***$^{-}$ **(by reflection and transmission) sources**

$$
E_{vis\alpha}(h_{m'}{}^{-})E_{ir,\beta}(h_{m'}{}^{-}) = E^0{}_{vis\alpha}E^0{}_{ir,\beta}
$$

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

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

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

$$
\times \exp[i(2n+1)(h_m \tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF}+h_{m''}\tan\theta_{m'',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})]
$$

(3.5)

E[+] **(by reflection and transmission) and** ***E***[-] **sources**

$$E_{vis\alpha}(h_{m'}^{-})E_{ir,\beta}(h_{m'}^{-}) = E^{0}{}_{vis\alpha}E^{0}{}_{ir,\beta}$$

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

m'/m 界面の m 側：

E[+] **and** ***E***[-] **(by reflection and transmission) sources**

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

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

(3.7)

E[+] **(by reflection and transmission) and** ***E***[-] **sources**

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

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

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

$$
\times \exp[i h_{m'} \tan\theta_{m',SF} (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})]
$$

$$
\times \exp[i 2n (h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \qquad (3.8)
$$

m/m'' 界面の m 側：

***E*⁺ and *E*⁻ (by reflection and transmission) sources**

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

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

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

$$
\times \exp[i h_{m''} \tan\theta_{m'',SF} (-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})]
$$

$$
\times \exp[i (2n+1)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \qquad (3.9)
$$

***E*⁺ (by reflection and transmission) and *E*⁻ sources**

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

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

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

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

$$
\times \exp[i 2n (h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \qquad (3.10)
$$

m/m'' 界面の m'' 側：

***E*⁺ and *E*⁻ (by reflection and transmission) sources**

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

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

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

$$\times \exp[ih_{m''} \tan\theta_{m'',SF}(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})]$$

$$\times \exp[i(2n+1)(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \quad (3.11)$$

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

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

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

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

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

$$\times \exp[i2n(h_m \tan\theta_{m,SF} + h_{m'} \tan\theta_{m',SF} + h_{m''} \tan\theta_{m'',SF})(-k_{m,ir} \sin\theta_{m,ir} - k_{m,vis} \sin\theta_{m,vis})] \quad (3.12)$$

m' 層の深さ z_1 点：

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

$$E_{vis\alpha}(z_1) E_{ir,\beta}(z_1) = E^0_{\ vis\alpha} E^0_{\ ir,\beta}$$

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

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

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

$$\times \exp[iz_1(k_{m',vis} \cos\theta_{m',vis}(1 + \tan\theta_{m',SF} \tan\theta_{m',vis})]$$

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

$$\times \exp[iz_1(k_{m',vis} \cos\theta_{m',vis}(-1 + \tan\theta_{m',SF} \tan\theta_{m,vis})]\}$$

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

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

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

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

m 層の m'/m 界面から深さ z_2 の点：

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

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

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

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

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

m" 層の m/m" 界面から深さ z_3 の点：

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

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

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

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

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

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

$$\begin{aligned}&\times\{\exp[iz_3(k_{m'',vis}\cos\theta_{m'',vis}(1-\tan\theta_{m'',SF}\tan\theta_{m'',vis})]\\&+r_{m''2,vis\alpha}e^{2i(\beta_{m vis}h_m+\beta_{m'' vis}h_{m''})}\exp[iz_3(k_{m'',vis}\cos\theta_{m'',vis}(-1-\tan\theta_{m'',SF}\tan\theta_{m'',vis})]\}\\&\times\{\exp[iz_3(k_{m'',ir}\cos\theta_{m'',ir}(1-\tan\theta_{m'',SF}\tan\theta_{m'',ir})]\\&+r_{m''2,ir,\beta}e^{2i(\beta_{m ir}h_m+\beta_{m'' ir}h_{m''})}\exp[iz_3(k_{m'',ir}\cos\theta_{m'',ir}(-1-\tan\theta_{m'',SF}\tan\theta_{m'',ir})]\}\\&\times\exp[i2n(h_m\tan\theta_{m,SF}+h_{m'}\tan\theta_{m',SF}+h_{m''}\tan\theta_{m'',SF})(-k_{m,ir}\sin\theta_{m,ir}-k_{m,vis}\sin\theta_{m,vis})]\end{aligned}\quad(3.18)$$

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**

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

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

$$\times\frac{\{(1+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})[(1+r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) +(r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}]\}}{\{(1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) +(r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}}\quad(3.19)$$

1/m' 界面の m' 側：

***E*⁺ and *E*⁻ (by reflection and transmission) sources**

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

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

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

m''/2 界面の2 側：

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

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

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

$$\times\frac{t_{1m',ir,\beta}t_{m'm,ir,\beta}t_{mm'',ir,\beta}t_{m''2,ir,\beta}e^{i(\beta_{m'',ir}h_{m''}+\beta_{m,ir}h_m+\beta_{m'',ir}h_{m''})}}{\{(1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}} \tag{3.21}$$

m''/2 界面の m'' 側：

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

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

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

$$\times\frac{t_{1m',ir,\beta}t_{m'm,ir,\beta}t_{mm'',ir,\beta}(1+r_{m''2,ir,\beta})e^{i(\beta_{m'',ir}h_{m''}+\beta_{m,ir}h_m+\beta_{m'',ir}h_{m''})}}{\{(1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}} \tag{3.22}$$

m'/m 界面の m' 側：

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

$$P_a^*(h_{m'}{}^-)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$

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

$$\times \frac{\{t_{1m',ir,\beta}e^{i\beta_{m',ir}h_{m'}}(1+r_{m'm,ir,\beta})[(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}]\}}{\{(1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}} \tag{3.23}$$

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

$$P_a^*(h_{m'}^-) = \sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$

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

$$\times \frac{\{t_{1m',ir,\beta}e^{i\beta_{m',ir}h_{m'}}(1+r_{m'm,ir,\beta})[(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{m'm,ir,\beta}+e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}]\}}{\{(1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}} \tag{3.24}$$

m'/m 界面 のm 側：

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

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

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

$$\times \frac{t_{1m',ir,\beta}t_{m'm,ir,\beta}e^{i\beta_{m',ir}h_{m'}}[(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}]}{\{(1+r_{1m',ir,\beta}r_{m'm,ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}}) + (r_{m'm,ir,\beta}+r_{1m',ir,\beta}e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}} \tag{3.25}$$

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

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

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

$$\times\frac{t_{1m',ir,\beta}\,t_{m'm,ir,\beta}\,e^{i\beta_{m',ir}h_{m'}}\left[(1+r_{mm'',ir,\beta}\,r_{m''2,ir,\beta}\,e^{2i\beta_{m'',ir}h_{m''}})+(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}\,e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\right]}{\{(1+r_{1m',ir,\beta}\,r_{m'm,ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}\,r_{m''2,ir,\beta}\,e^{2i\beta_{m'',ir}h_{m''}})+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}\,e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}} \tag{3.26}$$

m/m'' 界面の m 側：

E[+] **and** ***E***[-] **(by reflection and transmission) sources**

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

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

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

E[+] **(by reflection and transmission) and** ***E***[-] **sources**

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

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

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

m/m'' 界面の m'' 側：

E[+] **and** ***E***[-] **(by reflection and transmission) sources**

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

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

$$\times\frac{t_{1m',ir,\beta}\,t_{m'm,ir,\beta}\,t_{mm'',ir,\beta}\,e^{i(\beta_{m',ir}h_{m'}+\beta_{m,ir}h_m)}(1+r_{m''2,ir,\beta}\,e^{2i\beta_{m'',ir}h_{m''}})}{\{(1+r_{1m',ir,\beta}\,r_{m'm,ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})(1+r_{mm'',ir,\beta}\,r_{m''2,ir,\beta}\,e^{2i\beta_{m'',ir}h_{m''}})+(r_{m'm,ir,\beta}+r_{1m',ir,\beta}\,e^{2i\beta_{m',ir}h_{m'}})(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}\,e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}\}} \tag{3.29}$$

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

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

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

$$\times \frac{t_{1m',ir,\beta} t_{m'm,ir,\beta} t_{mm'',ir,\beta} e^{i(\beta_{m',ir} h_{m'} + \beta_{m,ir} h_m)} (1 + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}})}{\{(1 + r_{1m',ir,\beta} r_{m'm,ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) + (r_{m'm,ir,\beta} + r_{1m',ir,\beta} e^{2i\beta_{m',ir} h_{m'}})(r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) e^{2i\beta_{m,ir} h_m}\}} \tag{3.30}$$

m' 層の深さ z_1 点：

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

$$P_a^*(z_1) = \sum_{\alpha,\beta} \chi_{a\alpha\beta} E^0{}_{vis\alpha} E^0{}_{ir,\beta}$$

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

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

$$\times \{[(1 + r_{mm'',vis\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m'vis} h_{m''}}) + r_{m'm,vis\alpha} (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m'vis} h_{m''}}) e^{2i\beta_{mvis} h_m}]$$
$$\times \exp[iz_1 (k_{m',vis} \cos\theta_{m',vis} (1 + \tan\theta_{m',SF} \tan\theta_{m',vis})]$$
$$+ [r_{m'm,vis\alpha} (1 + r_{mm'',vis\,\alpha} r_{m''2,vis\alpha} e^{2i\beta_{m'vis} h_{m''}}) + (r_{mm'',vis\alpha} + r_{m''2,vis\alpha} e^{2i\beta_{m'vis} h_{m''}}) e^{2i\beta_{mvis} h_m}]$$
$$\times \exp[iz_1 (k_{m',vis} \cos\theta_{m',vis} (-1 + \tan\theta_{m',SF} \tan\theta_{m',vis})]\}$$

$$\times \{[(1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) + r_{m'm,ir,\beta} (r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'',ir} h_{m''}}) e^{2i\beta_{m\,ir} h_m}]$$
$$\times \exp[iz_1 (k_{m',ir} \cos\theta_{m',ir} (1 + \tan\theta_{m',SF} \tan\theta_{m',ir})]$$
$$+ [r_{m'm,ir,\beta} (1 + r_{mm'',ir,\beta} r_{m''2,ir,\beta} e^{2i\beta_{m'ir} h_{m''}}) + (r_{mm'',ir,\beta} + r_{m''2,ir,\beta} e^{2i\beta_{m'ir} h_{m''}}) e^{2i\beta_{mir} h_m}]$$
$$\times \exp[iz_1 (k_{m',ir} \cos\theta_{m',ir} (-1 + \tan\theta_{m',SF} \tan\theta_{m',ir})]\} \tag{3.31}$$

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

$$P_a^*(z_1) = \sum_{\alpha,\beta} \chi_{a\alpha\beta} E^0{}_{vis\alpha} E^0{}_{ir,\beta}$$

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

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

$$\times\{[(1+r_{mm'',vis\alpha}\, r_{m''2,vis\alpha}\, e^{2i\beta_{m''vis}h_{m''}})+r_{m'm,vis\alpha}(r_{mm'',vis\alpha}+r_{m''2,vis\alpha}\, e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{mvis}h_m}]$$
$$\times \exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(1-\tan\theta_{m',SF}\tan\theta_{m',vis})]$$
$$+[r_{m'm,vis\alpha}(1+r_{mm'',vis\alpha}\, r_{m''2,vis\alpha}\, e^{2i\beta_{m''vis}h_{m''}})+(r_{mm'',vis\alpha}+r_{m''2,vis\alpha}\, e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{mvis}h_m}]$$
$$\times \exp[iz_1(k_{m',vis}\cos\theta_{m',vis}(-1-\tan\theta_{m',SF}\tan\theta_{m',vis})]\}$$

$$\times\{[(1+r_{mm'',ir,\beta}\, r_{m''2,ir,\beta}\, e^{2i\beta_{m'',ir}h_{m''}})+r_{m'm,ir,\beta}(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}\, e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{m,ir}h_m}]$$
$$\times \exp[iz_1(k_{m',ir}\cos\theta_{m',ir}(1-\tan\theta_{m',SF}\tan\theta_{m',ir})]$$
$$+[r_{m'm,ir,\beta}(1+r_{mm'',ir,\beta}\, r_{m''2,ir,\beta}\, e^{2i\beta_{m''ir}h_{m''}})+(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}\, e^{2i\beta_{m''ir}h_{m''}})e^{2i\beta_{mir}h_m}]$$
$$\times \exp[iz_1(k_{m',ir}\cos\theta_{m',ir}(-1-\tan\theta_{m',SF}\tan\theta_{m',ir})]\} \qquad (3.32)$$

m 層の m'/m 界面から深さ z_2 の点：

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

$$P_a^*(h_{m'}+z_2)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$

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

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

$$\times\{(1+r_{mm'',vis\alpha}\, r_{m''2,vis\alpha}\, e^{2i\beta_{m'',vis}h_{m''}})\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(1+\tan\theta_{m,SF}\tan\theta_{m,vis})]$$
$$+(r_{mm'',vis\alpha}+r_{m''2,vis\alpha}\, e^{2i\beta_{m''vis}h_{m''}})e^{2i\beta_{mvis}h_m}\exp[iz_2(k_{m,vis}\cos\theta_{m,vis}(-1+\tan\theta_{m,SF}\tan\theta_{m,vis})]\}$$
$$\times\{(1+r_{mm'',ir,\beta}\, r_{m''2,ir,\beta}\, e^{2i\beta_{m'',ir}h_{m''}})\exp[iz_2(k_{m,ir}\cos\theta_{m,ir}(1+\tan\theta_{m,SF}\tan\theta_{m,ir})]$$
$$+(r_{mm'',ir,\beta}+r_{m''2,ir,\beta}\, e^{2i\beta_{m'',ir}h_{m''}})e^{2i\beta_{mir}h_m}\exp[iz_2(k_{m,ir}\cos\theta_{m,ir}(-1+\tan\theta_{m,SF}\tan\theta_{m,ir})]\} \qquad (3.33)$$

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

$$P_a^*(h_{m'}+z_2)=\sum_{\alpha,\beta}\chi_{a\alpha\beta}E^0{}_{vis\alpha}E^0{}_{ir,\beta}$$

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

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

m" 層の m/m" 界面から深さ z_3 の点：

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

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

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

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