$$\boldsymbol{H}_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} L_\mathrm{i} \\ L_\mathrm{m} \end{bmatrix} = \boldsymbol{H}_2^{-1} \begin{bmatrix} L_\mathrm{d} \\ L_\mathrm{q} \end{bmatrix} \tag{2}$$

$$\begin{bmatrix} g_\mathrm{pi} & g_\mathrm{pm} \\ g_\mathrm{ni} & g_\mathrm{nm} \end{bmatrix} = A_\mathrm{pn}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} (1+K)L_\mathrm{i} & -(1-K)L_\mathrm{m} \\ (1-K)L_\mathrm{i} & -(1+K)L_\mathrm{m} \end{bmatrix} \tag{3}$$

$$= A_\mathrm{pn}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} 1+K & -(1-K) \\ 1-K & -(1+K) \end{bmatrix} \begin{bmatrix} L_\mathrm{i} \\ L_\mathrm{m} \end{bmatrix} \tag{4}$$

$$\begin{bmatrix} c_\mathrm{p} & c_\mathrm{n} \\ s_\mathrm{p} & s_\mathrm{n} \end{bmatrix} = \begin{bmatrix} g_\mathrm{pi} + g_\mathrm{pm}\cos(2\theta_\gamma) & g_\mathrm{ni} + g_\mathrm{nm}\cos(2\theta_\gamma) \\ g_\mathrm{pm}\sin(2\theta_\gamma) & g_\mathrm{nm}\sin(2\theta_\gamma) \end{bmatrix} \tag{5}$$

$$= \begin{bmatrix} 1 & \cos(2\theta_\gamma) \\ 0 & \sin(2\theta_\gamma) \end{bmatrix} \begin{bmatrix} g_\mathrm{pi} & g_\mathrm{ni} \\ g_\mathrm{pm} & g_\mathrm{nm} \end{bmatrix} \tag{6}$$

$$\begin{bmatrix} \tilde{c}_\mathrm{p} \\ \tilde{s}_\mathrm{p} \end{bmatrix} = [c_\mathrm{p}\boldsymbol{I} + s_\mathrm{p}\boldsymbol{J}]\boldsymbol{u}_\mathrm{p}(\theta_\mathrm{he}) \tag{7}$$

$$\begin{bmatrix} \tilde{c}_\mathrm{n} \\ \tilde{s}_\mathrm{n} \end{bmatrix} = [c_\mathrm{n}\boldsymbol{I} + s_\mathrm{n}\boldsymbol{J}]\boldsymbol{u}_\mathrm{n}(\theta_\mathrm{he}) \tag{8}$$

$$\Leftrightarrow \begin{bmatrix} \tilde{c}_\mathrm{p} & \tilde{c}_\mathrm{n} \\ \tilde{s}_\mathrm{p} & -\tilde{s}_\mathrm{n} \end{bmatrix} = \boldsymbol{R}(\theta_\mathrm{he}) \begin{bmatrix} c_\mathrm{p} & c_\mathrm{n} \\ s_\mathrm{p} & -s_\mathrm{n} \end{bmatrix} \tag{9}$$

$$\boldsymbol{R}(\theta) \equiv \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix} \tag{10}$$

$$\boldsymbol{u}_\mathrm{p}(\theta) \equiv \begin{bmatrix} \cos(\theta) \\ \sin(\theta) \end{bmatrix} \tag{11}$$

$$\boldsymbol{u}_\mathrm{n}(\theta) \equiv \begin{bmatrix} \cos(\theta) \\ -\sin(\theta) \end{bmatrix} \tag{12}$$

$$\begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} = (\boldsymbol{I} - \boldsymbol{J}) \begin{bmatrix} c_\mathrm{p} & s_\mathrm{p} \\ c_\mathrm{n} & -s_\mathrm{n} \end{bmatrix} \tag{13}$$

$$\begin{bmatrix} c_\mathrm{p} & s_\mathrm{p} \\ c_\mathrm{n} & -s_\mathrm{n} \end{bmatrix} = \begin{bmatrix} g_\mathrm{pi} + g_\mathrm{pm}\cos(2\theta_\gamma) & g_\mathrm{pm}\sin(2\theta_\gamma) \\ g_\mathrm{ni} + g_\mathrm{nm}\cos(2\theta_\gamma) & -g_\mathrm{nm}\sin(2\theta_\gamma) \end{bmatrix} \tag{14}$$

$$= A_\mathrm{pn}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} (1+K)L_\mathrm{i} - (1-K)L_\mathrm{m}\cos(2\theta_\gamma) & -(1-K)L_\mathrm{m}\sin(2\theta_\gamma) \\ (1-K)L_\mathrm{i} - (1+K)L_\mathrm{m}\cos(2\theta_\gamma) & (1+K)L_\mathrm{m}\sin(2\theta_\gamma) \end{bmatrix} \tag{15}$$

$$\begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} = A_\mathrm{pn}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} (1+K)L_\mathrm{i} - (1-K)L_\mathrm{m}\cos(2\theta_\gamma) & -(1-K)L_\mathrm{m}\sin(2\theta_\gamma) \\ (1-K)L_\mathrm{i} - (1+K)L_\mathrm{m}\cos(2\theta_\gamma) & (1+K)L_\mathrm{m}\sin(2\theta_\gamma) \end{bmatrix} \tag{16}$$

$$= A_\mathrm{pn}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} 2L_\mathrm{i} - 2L_\mathrm{m}\cos(2\theta_\gamma) & 2KL_\mathrm{m}\sin(2\theta_\gamma) \\ -2KL_\mathrm{i} - 2KL_\mathrm{m}\cos(2\theta_\gamma) & 2L_\mathrm{m}\sin(2\theta_\gamma) \end{bmatrix} \tag{17}$$

$$= 2A_\mathrm{pn}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} L_\mathrm{i} - L_\mathrm{m}\cos(2\theta_\gamma) & KL_\mathrm{m}\sin(2\theta_\gamma) \\ -K(L_\mathrm{i} + L_\mathrm{m}\cos(2\theta_\gamma)) & L_\mathrm{m}\sin(2\theta_\gamma) \end{bmatrix} \tag{18}$$

$$\begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} = 2A_{\mathrm{pn}}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} L_\mathrm{i} - L_\mathrm{m}\cos(2\theta_\gamma) & KL_\mathrm{m}\sin(2\theta_\gamma) \\ -K(L_\mathrm{i} + L_\mathrm{m}\cos(2\theta_\gamma)) & L_\mathrm{m}\sin(2\theta_\gamma) \end{bmatrix} \tag{19}$$

$$\begin{bmatrix} \tilde{c}_\mathrm{p} & \tilde{s}_\mathrm{p} \\ \tilde{c}_\mathrm{n} & -\tilde{s}_\mathrm{n} \end{bmatrix} = \begin{bmatrix} c_\mathrm{p} & s_\mathrm{p} \\ c_\mathrm{n} & -s_\mathrm{n} \end{bmatrix} \boldsymbol{R}^\mathrm{T}(\theta_\mathrm{he}) \tag{20}$$

$$\begin{bmatrix} \tilde{c}_\gamma & \tilde{s}_\gamma \\ \tilde{c}_\delta & -\tilde{s}_\delta \end{bmatrix} = (\boldsymbol{I} - \boldsymbol{J}) \begin{bmatrix} \tilde{c}_\mathrm{p} & \tilde{s}_\mathrm{p} \\ \tilde{c}_\mathrm{n} & -\tilde{s}_\mathrm{n} \end{bmatrix} \tag{21}$$

$$= (\boldsymbol{I} - \boldsymbol{J}) \begin{bmatrix} c_\mathrm{p} & s_\mathrm{p} \\ c_\mathrm{n} & -s_\mathrm{n} \end{bmatrix} \boldsymbol{R}^\mathrm{T}(\theta_\mathrm{he}) \tag{22}$$

$$= \begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} \begin{bmatrix} \cos(\theta_\mathrm{he}) & \sin(\theta_\mathrm{he}) \\ -\sin(\theta_\mathrm{he}) & \cos(\theta_\mathrm{he}) \end{bmatrix} \tag{23}$$

$$= 2A_{\mathrm{pn}}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} L_\mathrm{i} - L_\mathrm{m}\cos(2\theta_\gamma) & KL_\mathrm{m}\sin(2\theta_\gamma) \\ -K(L_\mathrm{i} + L_\mathrm{m}\cos(2\theta_\gamma)) & L_\mathrm{m}\sin(2\theta_\gamma) \end{bmatrix} \begin{bmatrix} \cos(\theta_\mathrm{he}) & \sin(\theta_\mathrm{he}) \\ -\sin(\theta_\mathrm{he}) & \cos(\theta_\mathrm{he}) \end{bmatrix} \tag{24}$$

$$= 2A_{\mathrm{pn}}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} \left(L_\mathrm{i} - L_\mathrm{m}\cos(2\theta_\gamma)\right)\cos(\theta_\mathrm{he}) - KL_\mathrm{m}\sin(2\theta_\gamma)\sin(\theta_\mathrm{he}) & \left(L_\mathrm{i} - L_\mathrm{m}\cos(2\theta_\gamma)\right)\sin(\theta_\mathrm{he}) + KL_\mathrm{m}\sin(2\theta_\gamma)\cos(\theta_\mathrm{he}) \\ -K\left(L_\mathrm{i} + L_\mathrm{m}\cos(2\theta_\gamma)\right)\cos(\theta_\mathrm{he}) - L_\mathrm{m}\sin(2\theta_\gamma)\sin(\theta_\mathrm{he}) & -K\left(L_\mathrm{i} + L_\mathrm{m}\cos(2\theta_\gamma)\right)\sin(\theta_\mathrm{he}) + L_\mathrm{m}\sin(2\theta_\gamma)\cos(\theta_\mathrm{he}) \end{bmatrix} \tag{25}$$

- ↑ github の一番上の式と一緒

$$\boldsymbol{X} \equiv 2A_{\mathrm{pn}}(\bar{\omega}_\mathrm{h}) \begin{bmatrix} L_\mathrm{i} - L_\mathrm{m}\cos(2\theta_\gamma) & KL_\mathrm{m}\sin(2\theta_\gamma) \\ -K(L_\mathrm{i} + L_\mathrm{m}\cos(2\theta_\gamma)) & L_\mathrm{m}\sin(2\theta_\gamma) \end{bmatrix} \tag{26}$$

$$\boldsymbol{X}^{-1} = \det{}^{-1}(\boldsymbol{X}) \begin{bmatrix} L_\mathrm{m}\sin(2\theta_\gamma) & -KL_\mathrm{m}\sin(2\theta_\gamma) \\ K(L_\mathrm{i} + L_\mathrm{m}\cos(2\theta_\gamma)) & L_\mathrm{i} - L_\mathrm{m}\cos(2\theta_\gamma) \end{bmatrix} \tag{27}$$

$$\det(\boldsymbol{X}) = 2A_{\mathrm{pn}}(\bar{\omega}_\mathrm{h})\left((k^2+1)L_\mathrm{m}L_\mathrm{i} + (k^2-1)L_\mathrm{m}^2\cos(2\theta_\gamma)\right)\sin(2\theta_\gamma) \tag{28}$$

$$\boldsymbol{X}^{-1} \begin{bmatrix} \tilde{c}_\gamma & \tilde{s}_\gamma \\ \tilde{c}_\delta & -\tilde{s}_\delta \end{bmatrix} = \begin{bmatrix} \cos(\theta_\mathrm{he}) & \sin(\theta_\mathrm{he}) \\ -\sin(\theta_\mathrm{he}) & \cos(\theta_\mathrm{he}) \end{bmatrix} \tag{29}$$

$$\cos(\theta_\mathrm{he}) = \det{}^{-1}(\boldsymbol{X}) L_\mathrm{m}\sin(2\theta_\gamma)(\tilde{c}_\gamma - K\tilde{c}_\delta) \tag{30}$$

$$\sin(\theta_\mathrm{he}) = \det{}^{-1}(\boldsymbol{X}) L_\mathrm{m}\sin(2\theta_\gamma)(\tilde{s}_\gamma + K\tilde{s}_\delta) \tag{31}$$

$$\tan(\theta_\mathrm{he}) = \frac{\tilde{c}_\gamma - K\tilde{c}_\delta}{\tilde{s}_\gamma + K\tilde{s}_\delta} \tag{32}$$

- sympy のコードお借りしました
  - あってるみたいです

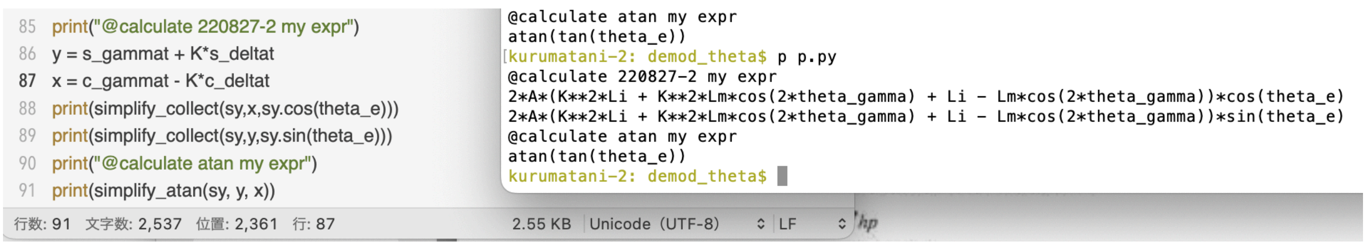

図 1.