Documentation for "COMPT-Time-Lag-RMS" Software

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March, 2020

1 Introduction

The "COMPT-Time-Lag-RMS" software consists of numerical codes to compute the energy dependent time-lag and r.m.s from a thermal Comptonized medium. The prescription is based on Kumar and Misra (2014) and details and assumptions are presented there.

The software computes the time and energy dependent time-lag when the (A) seed photon temperature is varied and (B) when the coronal heating rate is varied. The energy dependent time-lags are due to light travel timing affects due to Compton scattering in a medium.**The results can be compared with observed values, provided the time-lags are interpreted as such**.

This document describes the steps used in solving numerically the model developed by Kumar and Misra (2014). The differential equations involved in the model are described in the next section. However, For details please refer to the paper. Example results are shown in the last section.

THE README FILE GIVES INFORMATION REGARDING COMPILATION, RUNNING AND OUTPUT FILES

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2 The equations

Modelled equations are solved for two scenarios: 1.when input photon temperature varies and 2.when there is variation in coronal heating rate. The differential equations involved in respective cases is described below:

2.1 Case 1 (Variation in seed photon temperature):

- In the first scenario, following equations are needed

$$
\begin{aligned}
&-\frac{d^2\Delta n_\gamma}{dE^2} + \left(\frac{-1}{kT_{eo}} - \frac{2}{n_{\gamma o}}\frac{dn_{\gamma o}}{dE}\right)\frac{d\Delta n_\gamma}{dE} \\
&+ \frac{m_e c^2 t_c(\dot{n}_{s\gamma o} - i\omega n_{\gamma o})}{E^2 n_{\gamma o} kT_{eo}}\Delta n_\gamma = \left(\frac{-2}{E^2} + \frac{1}{n_{\gamma o}}\frac{d^2 n_{\gamma o}}{dE^2}\right)\Delta T_e \\
&+ \frac{m_e c^2 t_c \dot{n}_{s\gamma o}}{E^2 n_{\gamma o} kT_{eo}}\left(\frac{\frac{E}{kT_{bo}}}{1-\exp\left(\frac{-E}{kT_{bo}}\right)}\right)\Delta T_b
\end{aligned} \tag{1}
$$

$$
\begin{aligned}
\frac{3}{2}kT_{eo}\Delta T_e(i\omega) = \frac{\sigma_T c}{m_e c^2}\Bigg[\int 4kT_{eo}(\Delta T_e \\
+\Delta n_\gamma)n_{\gamma o}\ EdE - \int E^2 \Delta n_\gamma n_{\gamma o} dE\Bigg]
\end{aligned} \tag{2}
$$

- we solve *equations* (1) and (2) simultaneously using an iterative scheme (start with $\Delta T_b = (1,0), \Delta T_e = (0,0)$) till ΔT_e converges.

2.2 Case 2 (Variation in coronal heating rate):

- To get model parameter in the second scenario, we need *equation* (1) above and following two equations

$$
\begin{aligned}
\frac{3}{2}kT_{eo}\Delta T_e(-i\omega) = \dot{H}_{Exo}\Delta\dot{H}_{Ex} - \frac{\sigma_T c}{m_e c^2}\Bigg[\int 4kT_{eo}(\Delta T_e \\
+\Delta n_\gamma)n_{\gamma o}\ EdE - \int E^2 \Delta n_\gamma n_{\gamma o} dE\Bigg]
\end{aligned} \tag{3}
$$

$$
4\sigma(T_{bo})^4\Delta T_b = \frac{\eta V_c}{4\pi a^2}\int \frac{n_{\gamma o}}{(\tau^2+\tau)t_c}\Delta n_\gamma\ E\ dE \tag{4}
$$

- we solve *equations* $(1), (3)$ and (4) simultaneously using an iterative scheme (start with $\Delta T_b = (0,0), \Delta T_e = (1,0)$) till it converges.

References

[1] Kumar, N. and Misra, R., 2014, MNRAS, 445, (2818-2824)

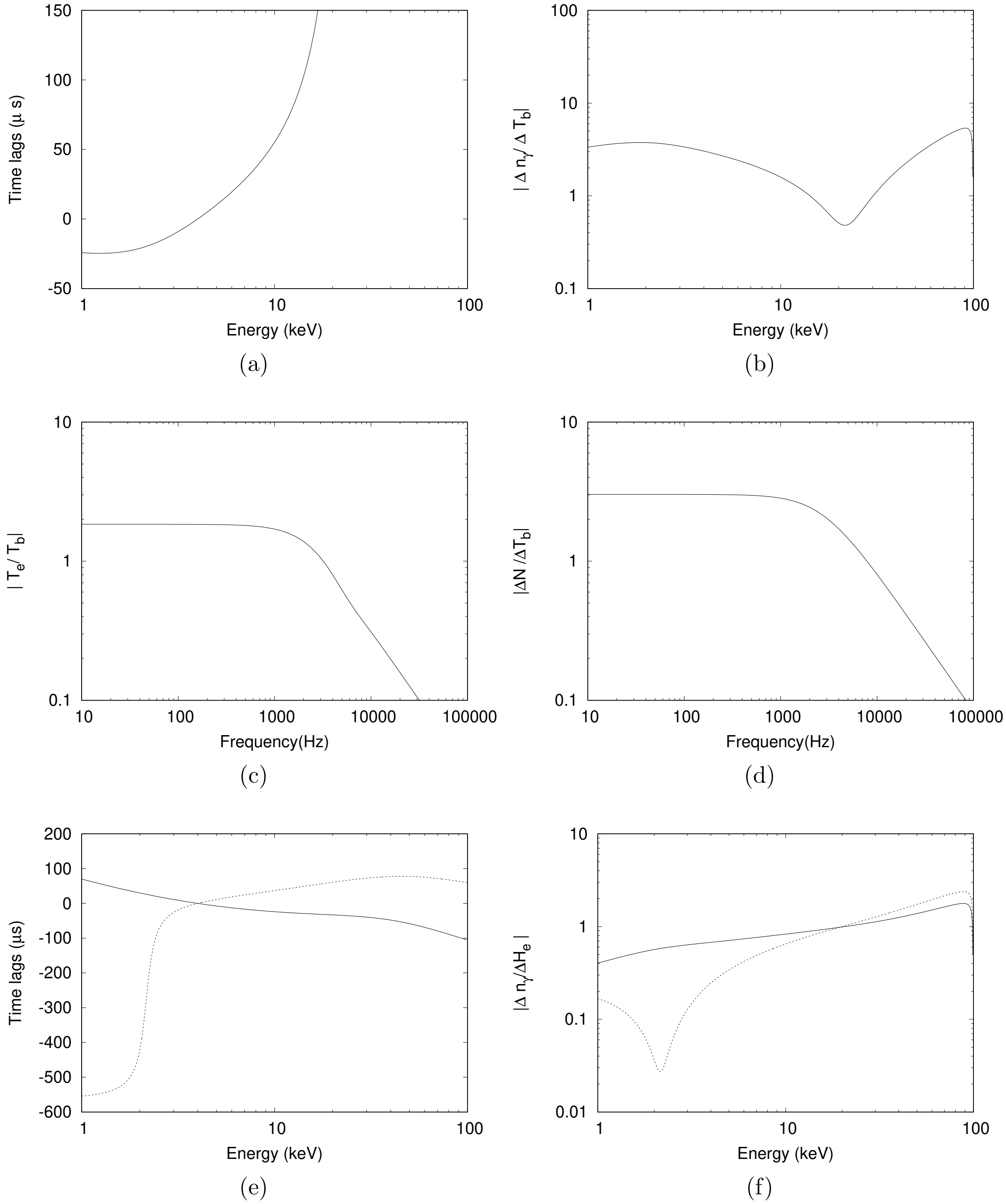

Figure 1: Plots of different outputs. First two rows are related to variation in seed photon temperature case while the bottom row shows the output related to the case when we consider variations in coronal heating rate.