Time-varying model of X-ray emission in pre-main sequence stars and its impact on disk evolution

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X-ray and ultraviolet (XUV) radiation from pre-main sequence stars is an important factor to control the gas evolution in protoplanetary disk through photoevaporation and ionization. They are originated from magnetic activities, such as coronae and flares, or gas accretion onto the central star. In particular, flares are a unique source of hard X-ray photons which drive a variety of chemical reactions in disk. Therefore, it is essential to understand the radiation-field of pre-main sequence stars and the disk evolution.

Flares are an explosive event with timescale of several hours or days. In most previous studies on disk evolution, however, constant XUV luminosity of a central star has been adopted for simplicity. On the other hand, both observational and theoretical studies have shown that abundances of some chemical species are variable corresponding to a short-time change in X-ray luminosity [1-3]. Although they provide an important clue that short-time variation in X-rays has a non-negligible effect on disk evolution, previous theoretical work [e.g., 2-3] still lack precise descriptions for flares, such as modelling individual flare property and hard X-ray component. Further studies that incorporate these missing factors are required to reveal the radiative property of pre-main sequence stars and disk chemistry.

In this study, we construct a model of the time-varying stellar X-ray based on stellar flare theories and stellar observations. We create the X-ray light curve of flares of pre-main sequence stars over > hundreds of years using the observed distribution of flare energy [4] (Figure 1). To see the variation in radiative properties, we also generate spectral energy distribution (SED) and its time evolution. We found the shape of SED is largely affected by occurrence of powerful flares which produce a significant amount of hard X-ray photons. We also discuss how these temporal variation in X-rays have effects on the ionization degree of the disk gas and abundance of chemical species.

References
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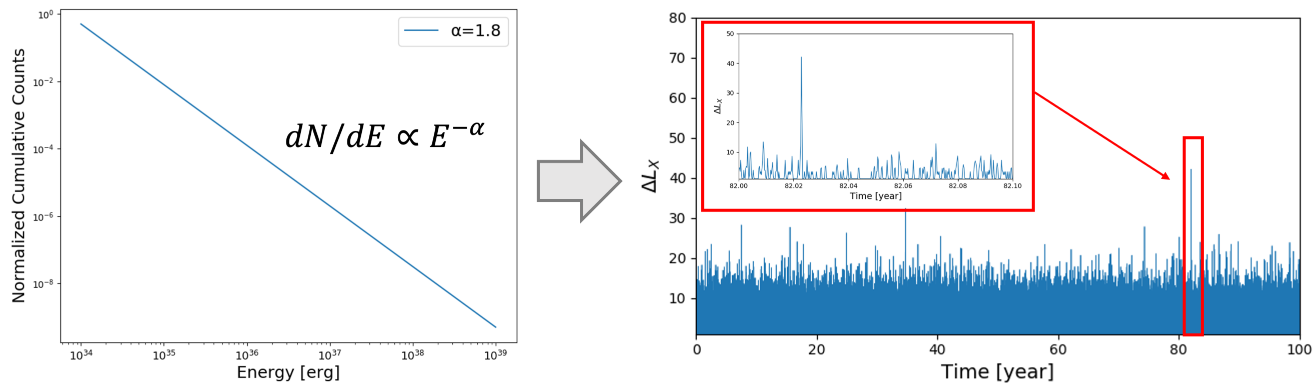

Figure 1. (left panel) Frequency distribution of PMS flare energy adopted in our model.
(right panel) An example of light curve over 100 years generated from the flare-energy distribution. Δ Lx is the relative change in the X-ray luminosity.