Feeding Compact Objects: Accretion on All Scales
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A Variability Study of Long-term Optical Data of OJ 287

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Abstract. In this paper, we investigated the possible exponential decays in the long term optical light curve of the BL Lac OJ 287. We developed a method that can be used to decomposing a light curve into a linear combination of exponential decays. The decomposing shows that the decay time scales range from $\sim 10^{3.6}$ to $\sim 10^{-4}$ days. The power spectra has frequency-dependent power-law with slop ~ 0.5, and the peak of power is at the time scale of decay on ~ 160 days.

Keywords. Quasar, OJ 287, time series analysis, method, exponential decay

1. Introduction

The OJ 287 ($z = 0.306$) is one of the best-observed quasars for which continuous light curve over more than one hundred years has been observed. Its optical curve provides us with good candidate for variability study.

As we known, some previous studies have employed power spectral techniques in the analysis of quasar optical light curves, and the power spectra of optical light curves is well described as **red noise** with $P(f) \propto 1/f^{\alpha}$ (Kelly *et al.* (2009), Giveon *et al.* (1999)). We also noted that some light curves of quasars showed quasi-exponential decays, it's can be explained by a model analogous to the relativistic blast-wave model (Böttcher & Principe (2009)). The power spectra of exponential decay has the form with $P(f) \propto 1/f^2$. So the question is whether the red noise is a combination of multi-components exponential decays? This work aims to looking for possible multi-components exponential decays in the light curve of OJ 287. We develop a similar spectral analysis method that it can be used to make a light curve decomposed into a linear combination of exponential decays.

2. Method and Results

The light curve can be regarded as a linear combination of exponential decays,

$$L(t) = \sum_{i=1}^{M} \sum_{j=1}^{N} A(\tau_i, t'_j)\, u(t - t'_j)\, \exp\left(-\left(t - t'_j\right)/\tau_i\right),$$

where the desired information is carried by the jumps $A(\tau_i, t'_j)$, τ_i is the time scale of the decay, t'_i is the start time of exponential decay. $u(t)$ is the step function. $A(\tau_i, t'_j)$ can be calculated with some kind of interative process.

For a given τ_i, the exponential decay process can be described as

$$l(\tau_i, t) = \sum_{j=1}^{N} A(\tau_i, t'_j)\, u(t - t'_j)\, \exp\left(-\left(t - t'_j\right)/\tau_i\right).$$

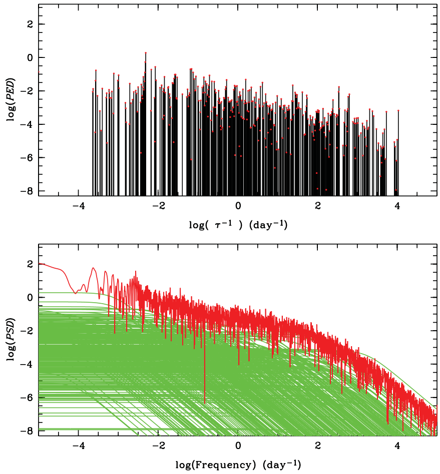

Figure 1. Top: Power of exponential decays of OJ 287. Bottom: Power spectra density of OJ 287 (red), power spectra densities of exponential decay with given α_i are also plotted(green).

The power of the exponential decay process (PED) with the decay time scale τ_i can be defined as the power of $l(\tau_i, t)$.

$$PED(a_i) = \frac{1}{N}\sum_{i=1}^{N} A^2(\tau_i, t'_j),$$

where $a_i = 1/\tau_i$ is the decay index. PED was plotted in the top of Fig 1.

The power spectra density of the exponential decay process has the form

$$PSD(f) = \left(\sum_{i=1}^{M}\sum_{j=1}^{N} A(\tau_i, t'_j)\,\frac{1}{\frac{1}{\tau_i} + i\,2\pi f}\right)^2 .$$

PSD was plotted in the bottom of Fig 1.

From Fig 1, we can see that the light curve can be decomposed into a linear combination of exponential decays. The decomposing shows that the decay time scales range from $\sim 10^{+3.6}$ to $\sim 10^{-4.0}$ days. The power spectra has frequency-dependent power-law with slop ~ 0.5, and the peak of power is at the time scale of decay on ~ 160 days.

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