OPTICAL VARIABILITY IN AGNS; DISK INSTABILITY OR STARBURSTS?

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1. Introduction

Aperiodic optical variability is a common property of Active Galactic Nuclei (AGN), though its physical origin is still open to question. We have compared light curves among the following two models and observation of quasar 0957+561A,B (Kundić et al. 1997) in terms of structure function analysis (§2).

Starburst (SB) model: Variability is due to random superposition of supernova light curves in the nuclear starburst region. In this study, we calculated a fluctuation light curve, following Aretxaga et al. (1997).

Disk-instability (DI) model: Variability is caused by some instabilities in the accretion disk around a supermassive black hole. We followed Mineshige et al. (1994) for the calculation methods, assuming that optical variability simply reflects X-ray variability.

K. Koyama et al. (eds.), The Hot Universe, 451-452.

2. Structure Function Analysis

When time series of magnitude [$m(t_i)$, $i = 1, 2, \ldots;\ t_i < t_j$] is given, the first-order structure function, $V(\tau)$, is defined as

$$V(\tau) \equiv \frac{1}{N(\tau)} \sum_{i<j} [\, m(t_i) \ - \ m(t_j)\,]^2 . \tag{1}$$

Summation is made over all pairs in which $t_j - t_i = \tau$, and $N(\tau)$ denotes a number of such pairs. Generally, $V(\tau)$ is described by a power-law below the typical timescale of shots;

$$[V(\tau)]^{1/2} \propto \tau^{\beta}. \tag{2}$$

We especially focus our attention to the logarithmic slope (β), since this distinguishes between the SB model and the DI model.

In addition, to evaluate the time-asymmetry of the light curve quantitatively, we separate $V(\tau)$ into two parts, $V_+(\tau)$ and $V_-(\tau)$, depending on the sign of $m(t_i) - m(t_j)$;

$$V_\pm(\tau) \equiv \frac{1}{N_\pm(\tau)} \sum_{i<j} [m(t_i) - m(t_j)]^2 \qquad \text{for} \quad m(t_i) - m(t_j) \gtrless 0, \tag{3}$$

where the summations in the expressions of $V_+(\tau)$ and $V_-(\tau)$ are made, respectively, only for pairs which have plus and minus signs of $[m(t_i) - m(t_j)]$, and $N_+(\tau)$ and $N_-(\tau)$ are the numbers of such pairs. A significant difference between $V_+(\tau)$ and $V_-(\tau)$, if it exists, indicates a deviation from time-symmetry of light curve. The results are as follows:

SB model; We find $\beta \sim 0.75 - 0.90$. There is a trend that $V_+(\tau) \gtrsim V_-(\tau)$, which means rapid rise and gradual decay in light curve.

DI model; We estimate $\beta \sim 0.41 - 0.49$. There is a slight tendency that $V_+(\tau) \lesssim V_-(\tau)$, which seems to reflect our neglect of hydrodynamical effects.

Observations (0957+561A,B); We have $\beta \sim 0.35$. A little time-asymmetry is shown $[V_+(\tau) \lesssim V_-(\tau)]$, but it is not clear whether the deviation is real or not. Longer observational data will clarify this issue.

In conclusion, the DI model is favored over the SB model to account for the statistical properties of the AGN optical light curve.

The details will be presented elsewhere (e.g., Kawaguchi et al. 1997).

References

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