VARIABILITY OF X-RAY EMISSION FROM CEN X-3 OBSERVED WITH GINGA

R. KANETAKE
Astronomical Institute, Tôhoku University, Sendai 980, Japan

T. TAKESHIMA
Institute of Space and Astronautical Science, Sagamihara 229, Japan

K. MAKISHIMA
Department of Physics, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan

and

M. TAKEUTI
Astronomical Institute, Tôhoku University, Sendai 980, Japan

Simplified stellar models like as one-zone models can be oscillated in chaotic state (Saitou *et al.* 1989). It is natural to consider that the irregular variations of Galactic X-ray sources might be caused from nonlinear oscillation of accretion disks or related flow. We studied the variability of Cen X-3 for applying the nonlinear theory to it.

The X-ray of Cen X-3 observed with Ginga from 22nd to 24th of March, 1989 are analyzed. Since Large Area Counters (LAC) of which the area of detector is 4,000 cm^2 are used. The data used here is obtained the range of 1,000 sec from 14 h 25 m on March 23rd with the time resolution of 0.25 sec. The energy bands are 1.7$\sim$4.6 keV, 4.6$\sim$9.3 keV, 9.3$\sim$19 keV, and 19$\sim$37 keV, respectively.

Takeshima *et al.* (1991) show that Cen X-3 is at the high state, when the X-ray from the source is not veiled by non-ionized matter (Schreier *et al.* 1976). So that we ignore the effect of circumstellar matter around the source.

First, we analyzed and obtained 4.817 sec by using the folding method. To search for deterministic chaos in the temporal behavior of Cen X-3, we used the method of VAS (Grassberger *et al.* 1983). We can obtain the second order dimension (Voges *et al.* 1987) by the following:

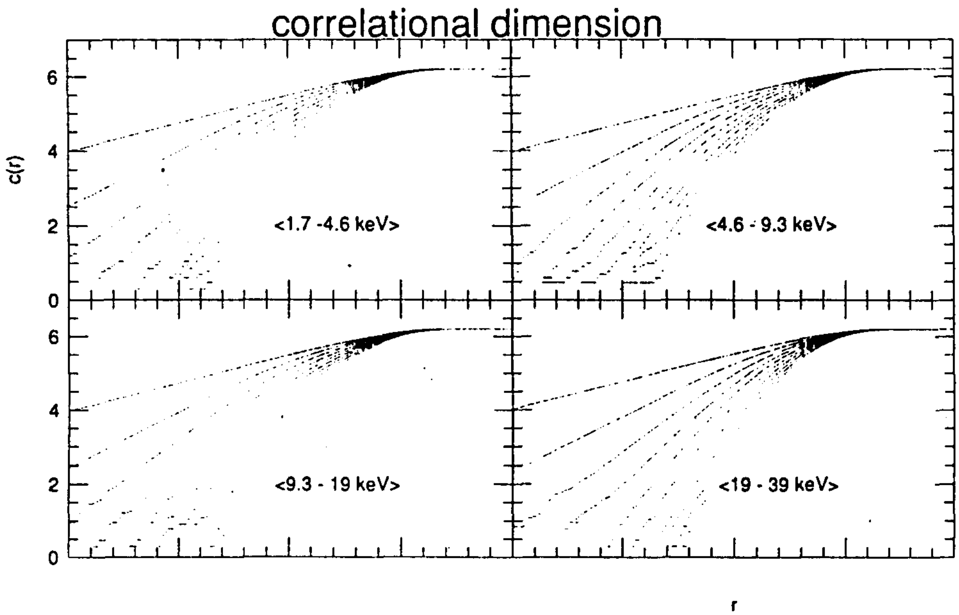
$$D_2 = \lim_{r \to 0} \frac{\log C(r)}{\log r}. \tag{1}$$

This is called the correlation dimension. Here $C(r)$ is defined as

$$C(r) = \lim_{N \to \infty} \frac{1}{N^2} \sum_{i,j=1}^{N} H(r - |X_i - X_j|), \tag{2}$$

where H: Heaviside function. If $C(r)$ can be described in the from,

Astrophysics and Space Science **210**: 113–115, 1993.



$$C(r) = r^{\nu}, \tag{3}$$

then ν is correlation dimension. Let X_i and X_j be vectors in a phase space of n dimensions. If each data set contains N, (N is the number of points), with a temporal resolution,

$$X_i = (x_i, x_{i+m}, \dots x_{i+(d-1)m}) \tag{4}$$

where d is called the embedding dimension. The resulting data sets X_i define a d-dimensional phase space, and the attractor can be reconstructed in the space. For each embedding dimension d, $C(r)$ expresses the number of distances which are less than r, and could obtain a slope ν. If the density of the calculated points is high enough, ν can't increase any more, so we could determine the number of d by a comparison of the slopes between successive values of $C(r)$. For example, if d is smaller than 3, then it will explain that the dimension phase-space for the attractor is less than three. Deviations from the averaged 4.8 sec oscillation are calculated. The deviations change point by point. Even though we tried to make a running average over 11 points, it still remains the irregularity. We analyzed the running averages of the every 4 energy bands by using a practical method (Sato *et al.* 1987). The result is illustrated in Fig. 1~4. It is shown that the embedding dimension is not so small as 3~4.

Since the irregular variation of all components is not a low-dimensional phenomena, the variability may express the fluctuation of accretion flow from the inner edge of the disk or related flow.

References

Grassberger, P. and Procaccia, I.: 1983, *Physical Review Letters* **50**, 346.
Kolláth, Z.: 1990, *Monthly Notices of the RAS* **247**, 377.
Nagase, F.: 1989, *Publications of the ASJ* **41**, 1.
Saitou, M., Takeuti, M., and Tanaka, Y.: 1989, *Publications of the ASJ* **41**, 297.
Sato, S., Sano, M., and Sawada, Y.: 1987, *Prog. Theor. Phys. (Letters)* **77**, 1.
Schreier, E. *et al.*: 1972, *Astrophysical Journal* **172**, L79.
Takeshima, T. *et al.*: 1991, *Publications of the ASJ* **43**, L43.
Voges, W. *et al.*: 1987, *Astrophysical Journal* **320**, 794.