OBSERVATIONS OF OPTICAL EMISSION FROM X-PER AND SCO X-1

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ABSTRACT

High speed photometric observations of X-per, and Sco X-1 have been carried out during 1979-80 with the 102 cm and 33 cm telescopes at the Kavalur observatory. Results from some of these observations are presented in this paper. Data on long term intensity variations at a level of $\Delta m = \pm 0.1$ and fast flickering in X-per are presented and discussed.

1. Introduction We present here optical observations of Sco X-1 and X-Per conducted during 1979-80. Observation on Sco X-1 was part of a world wide watch when it was observed simultaneously by SAS-3 satellite. X-Per observations were part of a regular high speed photometric programme. The instrument used consisted of a single channel dry ice cooled photometer for the observations with the 102 cm telescope and an uncooled single channel photometer with the 33 cm telescope. A schematic of the photometer is shown in the Fig-1. The output of the photometer was fed to a preampli-fier (response 100 MHz, rise time 10 ns) which in turn was connected to an amplifier discriminator (response 100 MHz, pulse pair resolution 4 ns). The output of discriminator was fed to a photon counter through a sampling/Control unit which worked as a buffer between counter and the printer (HP 5050B) to avoid the time delays due to the finite time taken by the printer. Data were collected with integration times ranging from 200 ms to 1 s. A chart recorded analog output served as quick took data.

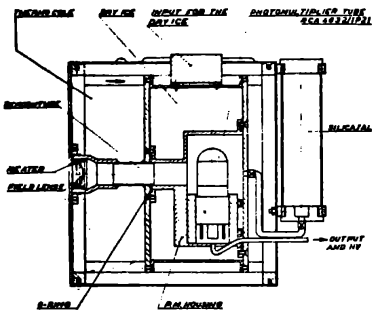

Fig:-1 The Photometer

2. Observations of Sco X-1 Sco X-1 was observed on March 8 and 9, 1979, when seeing was excellent. No significant flaring activity was observed during two days of observations. On March 8, 1979 occurrence of an "antiflare" is a major observation (Fig-2). The biggest antiflare lasted for about 70 s and was preceded by two small antiflares lasting each for 10 s (not shown) and 3 s. No other such event was recorded during the rest of the observations.

3. Observations of X-per X-per was observed on Aug 31, 1979 using 102 cm telescope in U-band for more than one hour. It was again monitored for a long time from Dec 27, 1979 to Jan 17, 1980 using 33 cm telescope. The total

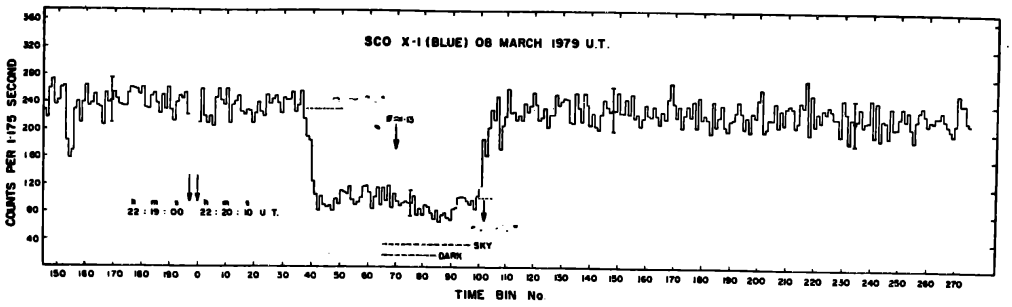

Fig-2: Sco X-1, Each time bin is about 1.175 s. observation time on the source was 23 hours during Dec-Jan period. The data collection time included monitoring of two comparison stars, viz, HR 1197 (V = 6.22, B-V = 0.22, U-B = 0.17) and HR 1164 (V = 6.25, B-V = 0.47). All the stretches of X-per were preceded and followed by comparison and background observations.

Part of the data collected in excellent seeing conditions on Aug 31 in U-band (102 cm telescope) is shown in Fig-3 where a plot of counts per second versus time is depicted. It was observed that the source showed a steady emission from 22.2014 hrs 23.3728 hrs. The source goes in a flaring mode from 23h 24m 7s when signal decreased by about 51% for about 6 s. The antiflare itself shows a double peak structure. We believe the phenomenon to be due to the star itself. A power spectrum analysis does not show any preferred periods.

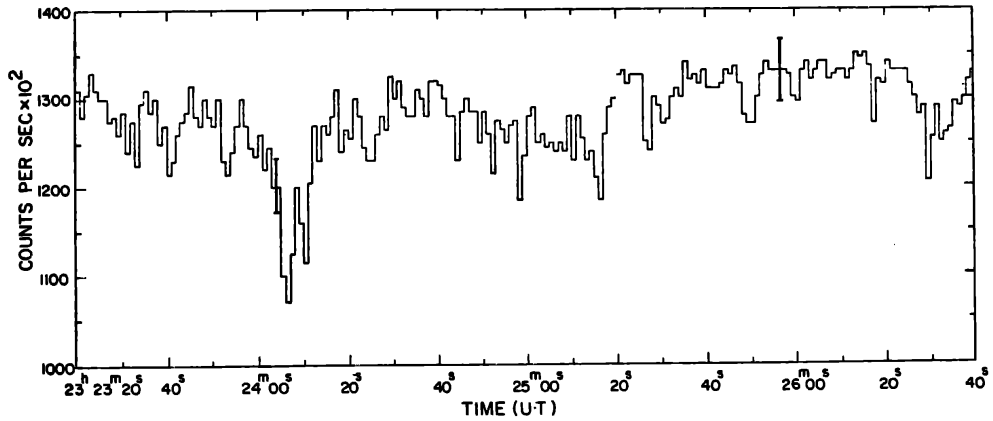

Fig:-3 Part of the 102 cm telescope X-per data

Data collected during Dec-Jan are shown in Fig-4 where differential magnitude (Δm) obtained with respect to the two comparisons and averaged over 5 s intervals is plotted. Examination of the entire data showed that the star did not vary by more than $\Delta m = 0.05$ on a long term basis. However, short term variations are clearly visible. Fig-4 shows that the U-band intensity on Dec 27 flickers by as large as $\Delta m = 0.2$ on time scales of few minutes. Observations after Dec 27 were mostly in B-band except for short runs in U and V to estimate U,B,V magnitudes, which showed that during this period B = 6.67 to 6.83, B-V = 0.126 to 0.216 and U-B = -0.86 to -0.873. The behaviour of the source was very

erratic on 29 Dec where it showed a slow decrease in Δm after 1850 hrs and a slow recovery by about 1900 hrs. There is a sudden drop in Δm from 0.4 to 0.3 around 1920 to 1930 hrs but the last two points show a recovery trend. The source recovered fully on 30 Dec with a stable condition that night.

The source shows again a very high value of Δm ($\sim$ 0.48) in the beginning on 14th Jan, the highest recorded value during observing period. The intensity drops back to normal an hour later. Remaining observations do not reveal any significant variations except a sudden drop in Δm on 17th Jan when value of Δm became 0.23 for a short while but recovered later.

3. Discussion The antiflares observed in the emission of Sco X-1 seem to be the only observation of its kind. The SAS-3 x-ray data do not show evidence for detection of any antiflare during this period. The change in the blue magnitude of the star ranged from 0.44 to 0.88 mag which is indeed very significant. More observations are therefore required to confirm thistype of phenomena in this source, which we plan to undertake in future. It is significant that the centre of the antiflare coincides with the minimum of the binary phase of the star (ϕ = 0.13)

X-per has been known to vary between magnitude 6 and 6.6 and comes under the category of Be stars with spectral type O9.5 Bo pe (Brucato and Kristian 1972, Crampton and Hutchings 1972, Ferrari toniolo et al 1977). It has been identified with a weak x-ray source 4U 0352+30 with an x-ray luminosity of $L_x = 5 \times 10^{33}$ ergs/s (Becker et al 1979) in 2-10 keV range. In x-ray range it pulsates with a period of 13.9 m. Hutchings (1974) has suggested it to be a spectroscopic binary of 580 d period.

We may point out that Campisi et al (1976) have also observed similar antiflare phenomena in X-per. Antiflares have also been reported by Pugach (1975) and recently by Mahmoud and Soliman (1981) in some flare stars. A Be star can be a rapidly rotating single star, an interacting binary, supergiant, an early type of nebular variable or a quasi-planetary nebula (Slattebak 1979). Their main characteristic is a shell formed around them (Struve 1931) and a continuous mass loss which is confirmed by UV observations (Slattebak 1979). The optical variability and antiflare phenomena that are observed by us in X-per seem to be associated with the varying shell around the primary and x-ray emission resulting from mass accretion by the secondary either from stellar wind or the shell or both.

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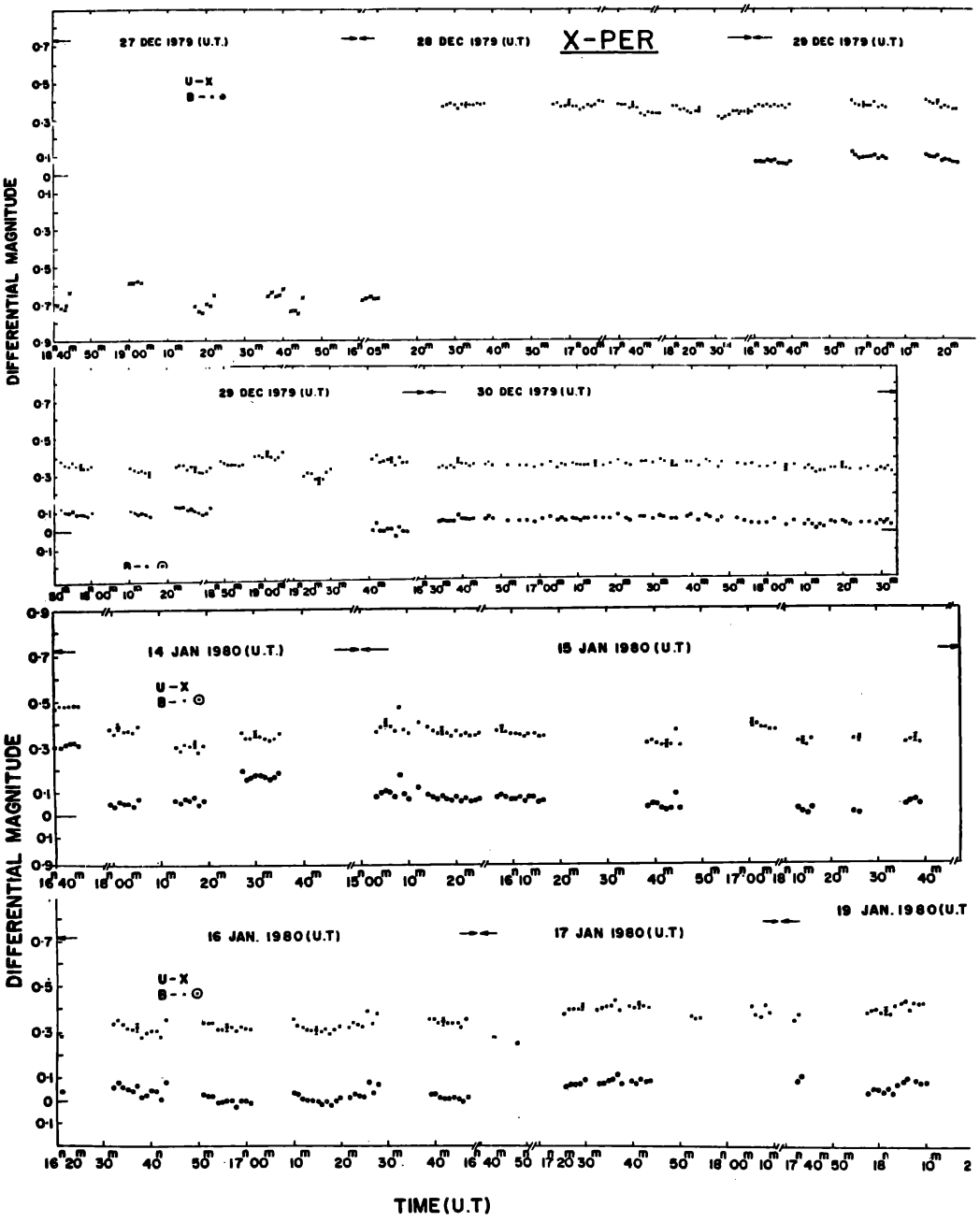

Fig-4: X-per observed with 33 cm telescope. Upper curve is derived with comparison-2.