ROSAT HRI OBSERVATIONS OF M33

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ABSTRACT

Our 35 ksec ROSAT HRI observation of M33 reveals 37 X–ray sources stronger than about 2.3σ. Eight of the sources are coincident with supernova remnants, four are coincident with giant HII regions, and three are coincident with HI holes. M33 X–7 is a compact accreting eclipsing binary, similar to binary X–ray sources detected in the Galaxy. Our ROSAT data confirm the binary interpretation and allow us to measure the period to an accuracy of 0.001%. The nuclear source, M33 X–8, is not found to be variable in the ROSAT HRI observations, although it varied as much as 40% between *Einstein* HRI observations.

1. Observations and Data Reduction

We observed M33 for 35 ksec with the High–Resolution Imager (HRI) on ROSAT in 1992 Jan and 1992 Aug. The two observation sections have pointing centers which differ by about 5″ so the August observations were shifted before being merged with the January observations. Sources were found using *ldetect* as well as by determining the count rates at the coordinates of HI holes (Deul & den Hartog 1990) and supernova remnants (Long et al. 1990). We find 37 X–ray sources stronger than about 2.3σ, of which eight are coincident with supernova remnants, four are coincident with giant HII regions, and three are coincident with HI holes. Twelve of the sources were previously detected with *Einstein Observatory* observations. Two *Einstein* sources, M33 X–12 and M33 X–15 (according to the classification of Trinchieri, Fabbiano, & Peres 1988 and Markert & Rallis 1983), were not detected with ROSAT, despite the much higher sensitivity of the observations.

2. Variability Analysis

We studied variability within the ROSAT observations with three independent methods: the Cramer–Smirnov–Von Mises method and the Kolmogorov–Smirnov method (Eadie et al. 1971) which compare the cumulative distribution of photon arrival times with the distribution expected from a constant source, and a modified χ^2 test able to provide binning independent results (Collura et al. 1987). All three tests indicate that M33 X–7 is variable at the 99.999% confidence level. We find no convincing evidence for variability in the other 14 sources that are strong enough to perform the variability analysis upon.

3. An Eclipsing Binary X–Ray Source

M33 X–7 was interpreted to be an eclipsing binary by Peres et al. (1989) based on *Einstein* observations. We confirm this interpretation and are able, because of the 12–year gap between the *Einstein* and ROSAT observations, to determine a much more accurate period, which we find to be 1.78572 ± 0.00001 days. The period we determine for M33 X–7 is very close to that of Her X–1 (Tananbaum et al. 1972) and the low phase lasts about a quarter of the period as in Cen X–3 (Schreier et al. 1972). A more thorough analysis of this source is presented in Schulman et al. (1993).

4. The Nuclear Source

The nuclear source, M33 X–8, does not appear to exhibit X–ray variability. We find the 3σ amplitude upper limit for variability to be 6% on timescales of 8700 seconds, and 17% on timescales of 40 seconds. It is puzzling that the X–ray flux changed by less than 1% between 1992 Jan and 1992 Aug, since it decreased by 40% between 1979 Aug and 1980 Jan, and increased by 20% between 1980 Jan and 1980 Aug (Peres et al. 1989).

The origin of the X–ray emission from M33 X–8 has been a mystery for some time (Markert & Rallis 1983). Its X–ray luminosity of about 10^{39} erg s^{-1} is low for an AGN but quite high for a Galactic X–ray source, although a number of sources outside the Local Group have been found with comparable or larger X–ray luminosities (most recently, Collura et al. (1994) determined the X–ray luminosity of a source in M82 to be at least 5.0×10^{39} erg s^{-1}). The nucleus has no detected 6 cm emission, no hydrogen line emission observed, little or no forbidden line emission, and infrared colors quite unlike those of AGN. Yet the young stars in the nucleus make up only a small fraction of the young population of M33, so that the *a priori* probability of a binary in the nucleus with an X–ray luminosity ten times that of any other source in M33 is small.

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References

Collura, A., Maggio, A., Sciortino, S., Serio, S., Vaiana, G. S., & Rosner, R. 1987, ApJ, 315, 340

Collura, A., Reale, F., Schulman, E., & Bregman, J. N. 1994, ApJ (Letters), in press

Deul, E. R., & den Hartog, R. H. 1990, A&A, 229, 362

Eadie, W. T., Drijard, D., James, F., Roos, M., & Sadoulet, B. 1971, Statistical Methods in Experimental Physics (Amsterdam: North–Holland)

Long, K. S., Blair, W. P., Kirshner, R. P, & Winkler, P. F. 1990, ApJS, 72, 61.

Markert, T. H., & Rallis, A. D. 1983, ApJ, 275, 571

Peres, G., Reale, F., Collura, A., & Fabbiano, G. 1989, ApJ, 336, 140

Schreier, E., Levinson, R., Gursky, H., Kellogg, E. M., Tananbaum, H., & Giacconi, R. 1972, ApJ, 172, L79

Schulman, E., Bregman, J. N., Collura, A., Reale, F., & Peres, G. 1993, ApJ, 418, L67

Tananbaum, H., Gursky, H., Kellogg, E. M., Levinson, R., Schreier, E., & Giacconi R. 1972, ApJ, 174, L143

Trinchieri, G., Fabbiano, G., & Peres, G., 1988, ApJ, 325, 531