STELLAR X-RAY ACTIVITY IN THE HYADES

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Observations of the Hyades cluster with the Einstein Observatory and with IUE have uncovered a high level of coronal x-ray emission ($L_x \simeq 10^{29}$ erg s^{-1} for solar-type stars) and similarly high fluxes of chromospheric and transition region line fluxes compared to the Sun (Stern et al.1981, Zolcinski et al. 1981, 1982). A giant x-ray flare from a spectroscopic binary system in the Hyades has also been reported (Stern, Antiochos and Underwood 1982).

In the original x-ray survey of Stern et al. (1981), roughly a 1-2 order-of magnitude spread was noted in the x-ray luminosities of solar-type stars in the Hyades. This was less than the apparent spread in x-ray luminosities of similar stars (of which there were only about 7) in the Vaiana et al. (1981) stellar x-ray survey. Although some of the difference between the two samples could be due to age effects (see, e.g., the review by Stern, 1982), the Hyades sample stars are all of the same age, requiring some combination of x-ray variability or an intrinsically broad distribution in x-ray luminosities, possibly the result of a similar spread in stellar rotational velocities (see, e.g., Pallavicini et al. 1981). A first step in determining the relative importance of each of these effects on the Hyades x-ray luminosity function is to estimate the range of x-ray variability in the cluster stars.

Here we report preliminary results from monitoring the x-ray emission of about 20 Hyades stars both on short ($\simeq$ 1 day or less), and long (3 months-2 years) time scales. All observations were made with the Imaging Proportional Counter of the Einstein Observatory (HEAO-2), and include a number of relatively short duration (2000 sec) exposures from the original x-ray survey of Stern et al. (1981) as well as a series of longer exposures (10,000 sec) of selected regions in the cluster center. Also, two exposures of 2000 s duration from an uncompleted program to study daily variations in stellar x-ray activity are included.

P. B. Byrne and M. Rodonò (eds.), Activity in Red-Dwarf Stars, 131–134.

Short Term Variability and Flaring.

In the Stern et al. (1981) 2000 s survey exposures, no evidence of x-ray flaring was observed. However, in the 10,000 s (22 - 25000 s duration) exposures of the followup survey, flaring was detected in three objects: the giant x-ray flare (10^{31} erg s^{-1} peak L_X) in the G dwarf/K dwarf spectroscopic binary (p = 5.6 d) BD + 16 577 (HD 27130), which had a 1/e decay time of $\simeq$ 40 min (Stern, Antiochos, and Underwood 1982); an increase in flux by about a factor of 2.5-3 in the GO V spectroscopic binary (p = 4 d) BD + 14 690 with a risetime of $\simeq$ 1000 s, and an upper limit to the decay time of $\simeq$ 2000 s (peak $L_X \simeq 10^{30.2}$ erg s^{-1}); and a factor of about 2 increase in L_X (peak $\simeq 10^{29.6}$ erg s^{-1}) for the K dwarf vA 500 over approximately the same time scale as for BD + 14 690.

In addition, there is evidence for a gradual decrease (by about a factor of two) in the observed flux from the dMe flare star vA 288 over the 25000 s duration of one of the follow-up observations.

Given that the total monitoring time on a given Hyades star was typically 7 hours or less (including data gaps), the discovery of three x-ray flares in three different Hyades stars may be an indication that flares at the level of 100 times or more brighter than typical solar flares are common in the stars of the Hyades cluster. We note, however, that two of three stars observed to flare are members of short-period (6 d.) binary systems. Also, since the detection threshold for flares is relatively high ($\simeq 10^{29}$ erg s^{-1}), we have likely observed only the brightest flaring activity in the cluster.

Long Term Monitoring

For about 20 stars, all F-M dwarfs except for the KO giant θ Tau, we have several observations over a time scale of up to 500 days. Within statistical uncertainties ranging from about 10 - 50%, slightly more than half of the stars show no statistically significant change in x-ray luminosity. θ Tau is among the stars with no evident change over the 1 - 1/2 year period. Except for the flaring activity noted in the previous section, the stars which do vary in L_X do so by no more than factors of 2-3 over the span of the observations. Although the length of our baseline is short compared to the typical 11 year length of the solar cycle, the absence of any very large long term changes in x-ray luminosity is intriguing. Thus coronally active Hyades stars do not show strong cyclic activity on time scales significantly less than a solar cycle. However, much more extensive long term monitoring is required to search for longer duration or weaker cyclic activity in the Hyades.

Summary

Our preliminary conclusions are that flaring behavior is probably common in the Hyades, but that the influence of binarity on the level of flaring

https://doi.org/10.1017/S0252921100096020 Published online by Cambridge University Press

activity needs to be investigated further. The long term observations suggest that intrinsic differences in the level of stellar x-ray luminosity may be required to account for the spread in the x-ray luminosity function for solar type stars observed in the original Stern et al.(1981) survey.

This work was performed under NASA contract to the Jet Propulsion Laboratory, California Institute of Technology. R.A.S. wishes to thank the staff of the Arcetri Astrophysical Observatory, Firenze, Italy for help with the final preparation of this manuscript.

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DISCUSSION

Evans: You mentioned occultations. These show that among the Hyades stars there is an extraordinary proportion which are multiple. In spite of this I am certain that we have not found all of them. So I would advise caution in interpreting the cause of the flaring. Allowance must be made for the possibility of faint companions being the source of activity.

Stern: That is a well taken point. In the case of the large flare I tend to the view that there is a system akin to the RS CVn systems. Equally large flares have been seen in such systems. Bernie Haisch discussed them earlier. This is a special type of binary system. So, unless there is an additional dMe star flaring with an energy in X-rays larger than that

typically seen in dMe flare stars' then I would stick to the RS CVn explanation. But I agree that there are probably a lot of undiscovered binaries.

Evans: I would suspect that at least 50% of the bright Hyades stars are binary.

https://doi.org/10.1017/S0252921100096020 Published online by Cambridge University Press