EINSTEIN OBSERVATIONS OF THE RHO OPHIUCHI DARK CLOUD: AN X-RAY XMAS TREE

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An extensive Guest Observation of the ρ Ophiuchi dark cloud region was conducted with the Einstein Observatory, featuring in particular repeated observations of several parts of the cloud, on timescales down to a day, or even hours. In all, 14 IPC and 3 HRI fields were obtained. Initially motivated by a search for a possible compact counterpart to the COS-B γ-ray source 2CG 353+16 (for which no evidence was found), the present study gave a wealth of data, which turned out to be mostly relevant to early stages of stellar evolution.

Among the most significant results:

a) About 50 weak sources were discovered in the 2°×2° area investigated. There is some evidence for up to 20 more sources. b) These sources form a class of X-ray sources, which are most likely pre-main-sequence or very young objects; only ∿ 1/2 of them are known to be so at present from "standard" criteria (optical, IR, etc.). c) Most sources are highly variable, largely beyond what could be caused by unknown gain fluctuations. Variability factors may reach one order of magnitude or more in a day. d) The overall distribution of the normalized amplitude variations follows a power-law.

We interpret the time variability in terms of strong stellar flares, which dominate the X-ray luminosity of the sources (this is the case in particular for the 9 T Tau stars we detect, out of the 11 contained in the investigated area). In one extreme case, we may even have observed the strongest stellar X-ray flare ever recorded.

Finally, we discuss several implications bearing on early stages of stellar evolution, and some consequences of the presence of X-ray active objects within dark clouds. Several comparisons are made with the Orion complex. Possible observational tests are suggested.

DISCUSSION

S. Strom: Is there a correlation between optical and X-ray absorption?

Montmerle: Within the rather large errors on the column densities N_H (caused by uncertainty in the IPC gain), typically a factor 3-5, the values N_H (X) and N_H (vis) agree well, for high values (10^{21} - 10^{22} cm^{-2}). For lower values of N_H, there seems to be non-absorption as derived from the X-rays, pointing to the possible existence of a dust-free circumstellar envelope or wind.

Giampapa: There exist multiple X-ray observations of the Pleiades Cluster that show stellar X-ray sources in one "picture" but not in the other. These X-ray variable sources can be identified as K and M flare stars. Therefore, there is corroborative evidence for your flare interpretation. I believe that these kinds of X-ray observations can be used to find new cluster members and/or verify cluster membership.

Montmerle: Thank you very much.