THE EINSTEIN SURVEY OF THE YOUNG STARS IN THE ORION NEBULA

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ABSTRACT. We report here on the complete EINSTEIN survey of Orion within the central 2° × 2° region centered on the Trapezium. We present an X-ray mosaic of the Nebula and a complete X-ray catalog (200 sources) for this very young cluster. In addition, we discuss in detail variability, early-type stars, solar-type stars, and K-M stars.

Variability. Of the 200 X-ray sources detected, at least 69 of them have exhibited variability in the sense that they were not detected in at least one field with a longer exposure time than a field in which they were detected. Of the 76 stellar candidates with color and/or spectral types, at least 27 are variable including 19 in the K-M spectral range. Most of the observed X-rays in Orion may arise as a consequence of continual "flaring," as suggested with regard to the pre-main sequence stars in the similarly youthful ρ Oph cloud.[1]

Early-Type Stars. The fourteen O-B5 stars detected (out of 22 observed) all exhibit X-ray luminosities and L_x/L_{bol} ratios similar to previously observed O and early B stars, possibly slightly more active. However, it is the later B stars that provide the newest and most interesting information. Previously, $\lesssim 3$ main sequence stars between spectral types B6-B9 were known to be X-ray emitters (F. Walter, private communication). With this investigation of the Orion Nebula, we have more than tripled the known sample (11 detected out of 24 observed). However, whether or not the X-ray emission can be properly attributed to these hot stars or, rather, to possible late-type companions remains to be determined; studies of radial-velocity variations of these stars and of the late-type B stars not detected should help us to answer that question.

Solar-Type Stars. These stars in Orion have yet to complete their evolution to the ZAMS; however, it is still instructive to compare the mean X-ray luminosity of these stars to that of the solar-type stars in older clusters such as the Pleiades[2] and the Hyades[3] and, also,

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with the solar-type field stars.[4] A $t^{-3/2}$ decay relationship[4] for these solar-type stars is inadequate in describing their behavior over more than three decades in log t.

In addition, using the reprocessed EINSTEIN data for these F7-G8 stars, we show that the weak correlation of X-ray activity with rotational velocity obtained for these solar-type stars by Smith, Pravdo, and Ku (1983)[5] is now even more doubtful. Hence, their conclusions concerning the roles that rapid rotation, youth, and circumstellar disks play in determining the X-ray luminosity of these stars are now questionable; in particular, the inverse relation between X-ray emission and circumstellar disk strength (based on absorption and emission signatures in the Na D lines[6]) is no longer substantiated by these data.

K-M Type Stars. A large fraction of these stars (39 of the 176 have already been identified as K-M stars) will almost certainly prove to be T-Tauri or "Naked" T-Tauri stars,[7] since their mean X-ray luminosity (log L_x = 30.96 ergs s^{-1} for just the detected ones) and mean L_x/L_{bol} ratio (=-2.86) are values consistent with those exhibited by those types of stars. In addition, as mentioned above, the fact that many (19) of these stars are variable in X-ray emission also supports the likelihood of their being pre-main sequence objects. With this large sample added to the large number already collected by Walter[7] and collaborators from the Tau-Aur and Oph regions, problems such as the population characteristics and X-ray mechanism of these stars should prove solvable.

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