The volume-limited A-star survey

Exploring the multiplicity of intermediate-mass stars

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Submitted by Mr Robert John De Rosa to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Physics, January, 2012.

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ABSTRACT

I present the results of the first volume-limited adaptive optics multiplicity survey of A-type stars. Using high-resolution observations obtained using adaptive optics instruments at five observatories, I have estimated the frequency of binary companions to a sample of 233 A-type stars within 60 parsecs. The survey is complete within a projected separation range of $56 < a[\mathrm{AU}] \leq 891$, and a companion mass ratio range of $0.05 \leq q \leq 1.00$, corresponding to the bottom of the Main Sequence for companions to A-type stars. The multiplicity fraction of the sample, when corrected for completeness, is measured to be $24.2\% \pm 3.5\%$, continuing the trend of increasing multiplicity as a function of increasing primary mass reported in previous volume-limited surveys of Solar-type and M-dwarf primaries. A companion mass ratio and separation distribution are constructed over the restricted separation range, and are compared with previous observations of lower-mass primaries and theoretical predictions. The mass ratio distribution is strongly skewed towards lower-mass companions, consistent with the formation of binary companions within large circumstellar disks, while the shape of the separation distribution is not fully resolved due to the incompleteness of the survey. Over the separation range to which the observations are sensitive, a significant separation dependence on the mass ratio is observed, with a greater frequency of lower-mass companions measured at wider separations.

Using this large dataset of adaptive optics observations, I have also explored the unexplained X-ray detection of a subset of A-type stars, whose interior structures theoretically preclude the generation of X-rays. By constructing two similarly sensitive samples of X-ray and non X-ray detected early-type stars, I have tested the hypothesis that an unresolved, lower-mass companion is responsible for the emission. A comparison of the fraction of targets with resolved binary companions within both samples reveals a significantly higher multiplicity fraction for the X-ray detected sample of A-type stars, consistent with the prediction of this companion hypothesis. I have also studied the orbital motions of thirteen A-type stars, and determined the dynamical mass of each system. These dynamical mass estimates are compared with theoretical values from stellar evolutionary models, with discrepancies between these values within several systems used as evidence of unresolved companions, providing potential targets for future interferometric and spectroscopic observations.

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