AN OPTICAL STUDY OF WIDE BINARIES IN M42 – PRELIMINARY RESULTS.

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We present preliminar results from a major survey for visual binaries in the Orion Nebular Cluster (ONC). We used a set of 26 images taken with the Advanced Camera for Surveys onboard the Hubble Space Telescope together with an Hα filter. Each image has an exposure time of 500 seconds.

We analysed individually 1051 stars and concluded that 781 satisfy our membership criteria for ONC. These criteria are based on the proper motion catalog published by Jones & Walker (1988) (we consider members those star with membership probability greater than 93%), the x-ray catalog published by Getman et al. (2005), Hα emission (our unpublished catalog) and irregular variability given by the General Catalog of Variable Stars.

We find 78 multiple systems in our catalog and 59, from these 78, are new systems in the separation range of 0.1$''$ to 1.5$''$, which for ONC (located at $\sim$ 450pc) corresponds to the range of 45 to 675 AU.

To eliminate the contamination by line-of-sight pairs, we determined the stellar density (Σ) with a radius of 30$''$ around each one of the 781 ONC members. The surface density of stars in the ONC is a steeply declining function, as shown in Figure 1.

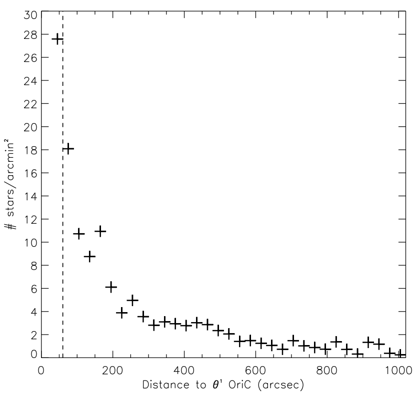

Figure 1: Surface density of stars in the ONC

The probability (P) of finding an unrelated star within a distance θ from each primary is calculated using the following formula, extracted from Correia et al. (2006):

$$P = 1 - e^{\pi\theta^2\Sigma} \quad (1)$$

In equation 1 θ was set to 1.5$''$. The probability (P) is principally a function of the distance from θ^1Ori C, with smaller variations due to local inhomogeneities in the cluster density.

The sum of fake-companion probabilities for the 781 ONC members is 911%, which means we have roughly 9 fake binaries in our sample. In order to be complete we limited our analysis to the systems in the separation range from 0.15$''$ to 1.5$''$, equivalent to 67.5 to 675 AU. Within this range we have 72 binaries and 3 triples (we count the 3 triples as 6 binaries). Correcting for the 9 line-of-sight doubles we then have 69 physical binaries, which implies a binary frequency of 8.8% $\pm$ 1.1% in the interval from 67.5 to 675 AU. In the inner 40$''$ $\times$ 40$''$ of the Trapezium, Petr et al. (1998) found 4 binaries in the separation range 0.14$''$ to 0.5$''$, which corresponds to a binary frequency of 5.9% $\pm$ 4.0%. In the same range we find 50 binaries and a binary frequency of 6.4% $\pm$ 0.9%. Nearby T Tauri associations were observed by Reipurth & Zinnecker (1993) who found 38 binaries (in a sample of 238 stars) in the range 150 to 1800 AU. In the common range, 150 to 675 AU, we find 5.3% $\pm$ 0.8% for the ONC and 11.8% $\pm$ 2.2% in the associations. In agreement with Petr et al. (1998) we find that the binary fraction in associations is higher by a factor of 2.2 compared to the ONC.

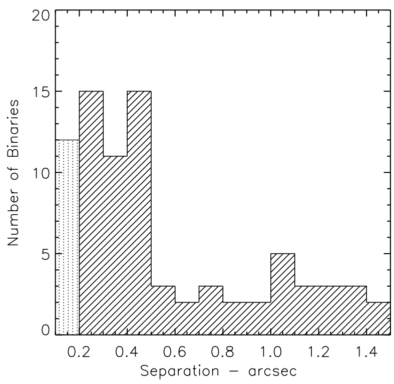

Figure 2: Angular separation distribution

Figure 2 shows the separation distribution function of binaries on an angular scale with bins 0.1$''$ wide. The first bin (0.1$''$ – 0.2$''$) is incomplete. There is a sudden decrease in the number of binaries as the separation increases beyond 0.5$''$, corresponding to 225 AU.

The separation distribution function on a logarithmic scale is complete over the whole separation range, as shown in Figure 3. The dot-dashed curve represents the Gaussian that Duquennoy & Mayor (1991) fitted to their entire data set while the dashed crosses represent their actual data points within our range.

Our binary frequency is 8.8% $\pm$ 1.1%, after the correction for false binaries, in the range 67.5 to 675 AU. The binary frequency from the Duquennoy & Mayor (1991) data set in the same range is 13.7%, using a simple trapezoidal approximation and 12.4% using a linear interpolation of their data points. It

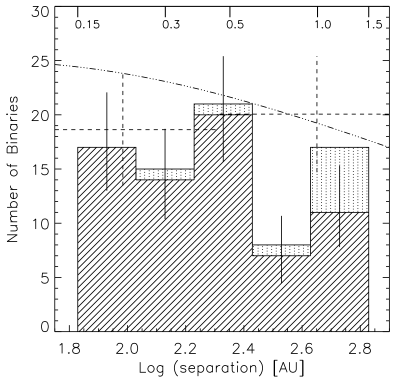

Figure 3: Separation distribution function in logarithmic scale

follows that in this range there is a factor of 1.41 to 1.56 more binaries in the field than in the ONC.

Is there a difference in the number of wide binaries relative to close binaries as we move from the dense inner regions to the outer reaches of the cluster? Based on the dramatic change in the separation distribution function at 0.5′′ we have chosen this separation as a dividing point, such that binaries in the range 0.15′′ to 0.5′′ are considered as "close" and binaries in the range 0.5′′ to 1.5′′ are considered as "wide"

In Figure 4 we show the ratio between wide to close binaries as a cumulative distribution, starting 30′′ after the exclusion zone, in other words, the first point is calculated at 90′′ from θ^1 Ori C. As the curve moves away from θ^1 Ori C it accounts for more and more binaries. The last point of the curve represents the mean ratio of wide to close binaries in the ONC (outside the exclusion zone). The dashed lines indicate 1σ errors. The dotted lines indicate the same ratio for the Duquennoy & Mayor binaries, calculated using their Gaussian fit (lower line) and their actual data points (upper line).

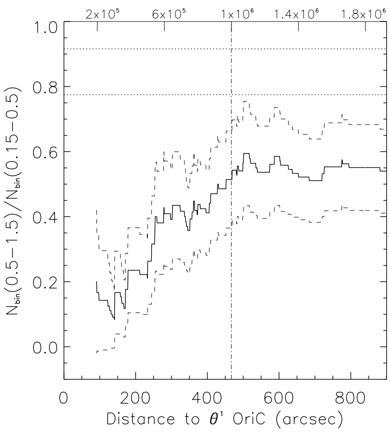

Figure 4: Cumulative distribution function

The upper axis, in Figure 4, shows the crossing time for different distances to the cluster center and suggests that for distances larger than roughly 460′′ there is no longer a measurable change in the ratio of wide to close binaries. The ratio changes by almost a factor of 4 – 5 from the inner to the outer regions, suggesting that many, if not most, of the wide binaries are disrupted within less than 5 passages in the cluster center. This is a most compelling observational evidence that dynamical interactions in the dense central region of the ONC have taken place. The dissolution of wide binaries could explain the lower number of binaries found in the ONC compared to associations. However, under certain circumstances such encounters could lead to a hardening of the binary making it closer than our resolution limit. In such case the binary is not lost to the full binary budget.

We are certain about one "brown dwarf – brown dwarf" binary in our sample. Infrared spectroscopy of the COUP 1061 source indicates a spectral type M9-L0 (Meeus & McCaughrean 2005). We have resolved this object into two components with almost equal brightness and a projected separation of 100 AU.

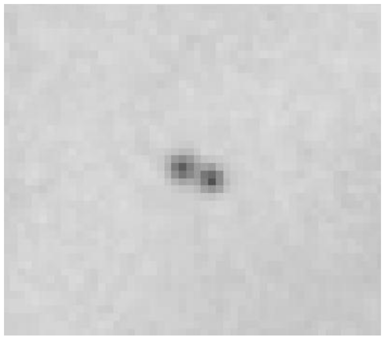

Figure 5: BD-BD candidate

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