Binary Formation in the Orion Nebula Cluster: Investigating the Low-mass Stellar and Sub-Stellar Population

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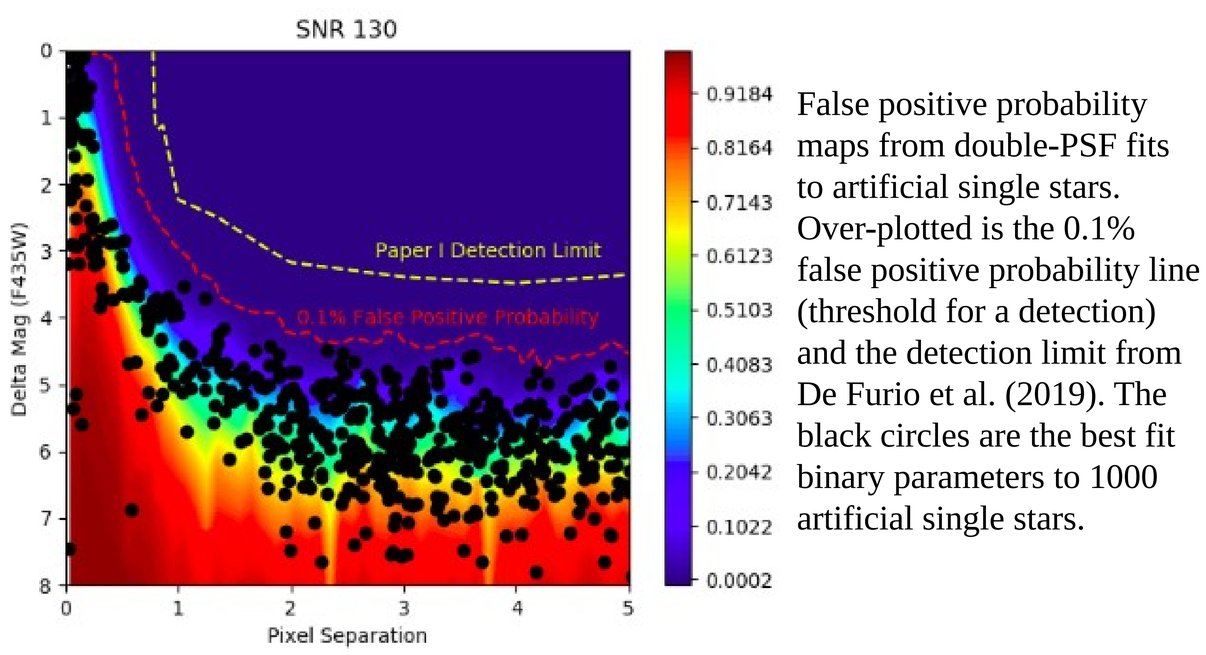
Motivation:

Multiplicity is a common aspect of star formation, whose properties depend on birth environment and primary mass. Studies in star-forming regions and the Galactic field show a trend in the mass ratio distribution based on primary mass [8, 11], while low-density associations contain an excess of stellar multiple systems relative to the Galactic field [7]. We investigate the multiplicity of the Orion Nebula Cluster (ONC), a high-density star-forming region, across primary masses 0.012 – 0.7 $M_\odot$ and place constraints on the companion population.

Method:

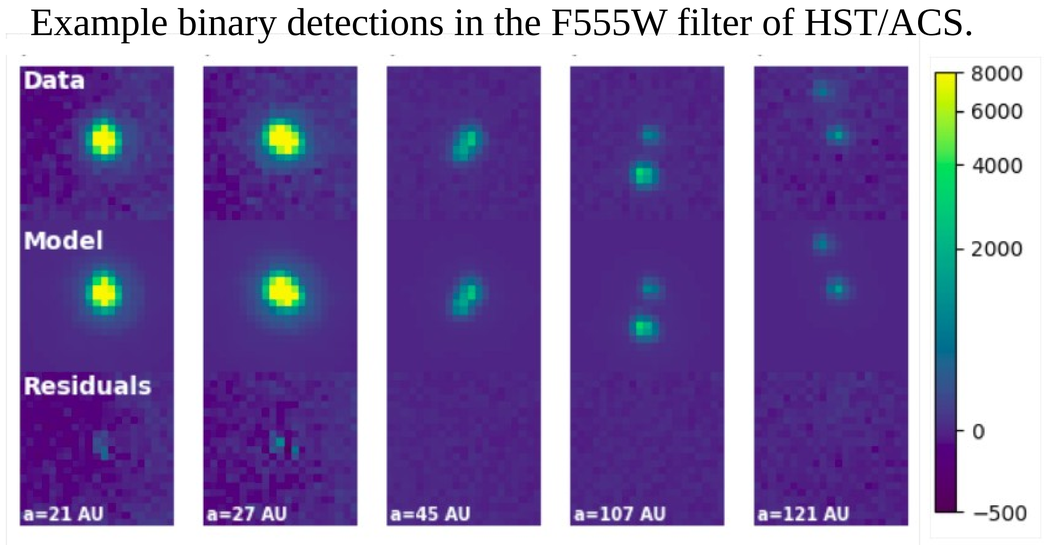
We developed a double point-spread function (PSF) fitting routine using empirical PSFs [2,3] to identify companions to clusters members [4, 6,9,12,14,15] within archival Hubble Space Telescope (HST) data on the Advanced Camera for Surveys (ACS) [13] in the ONC.

Results:

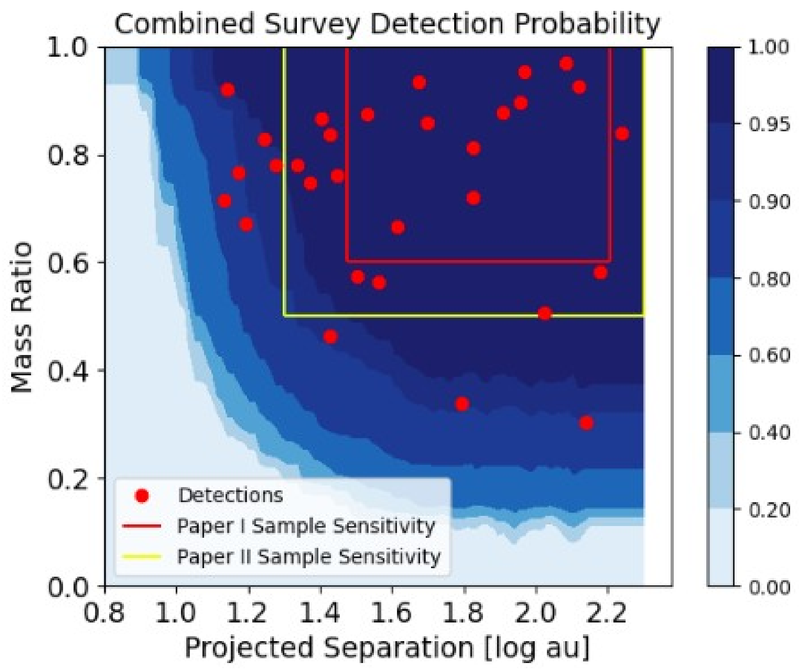


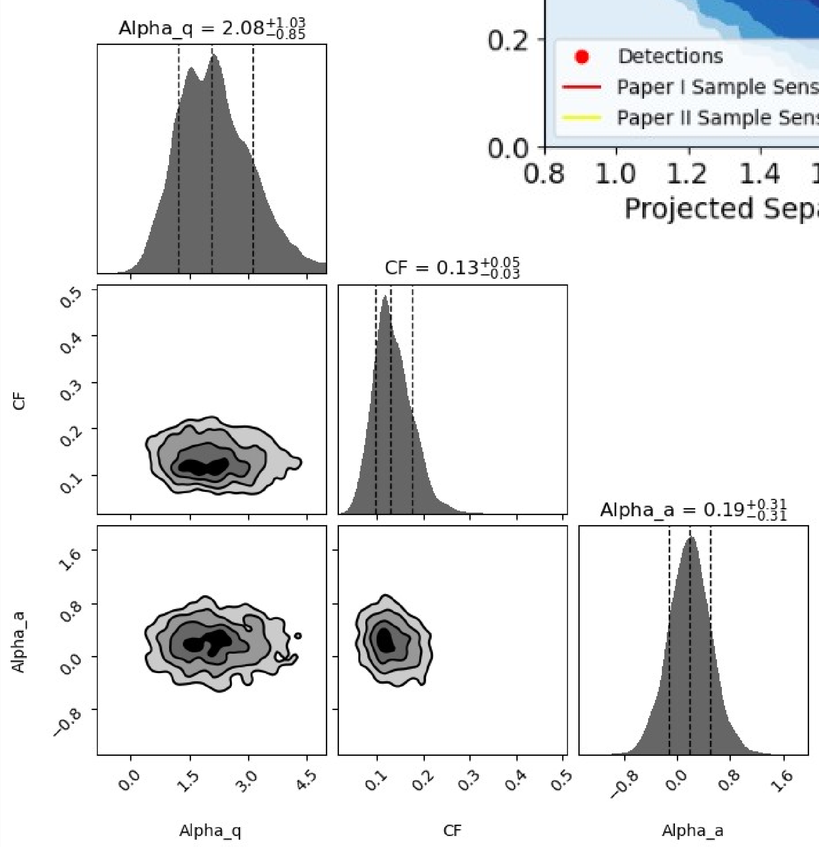
False positive probability maps from double-PSF fits to artificial single stars. Over-plotted is the 0.1% false positive probability line (threshold for a detection) and the detection limit from De Furio et al. (2019). The black circles are the best fit binary parameters to 1000 artificial single stars.

Example binary detections in the F555W filter of HST/ACS.



Combined sensitivity to companions for the low-mass stellar sample in the ONC. Over-plotted are lines of the shared sensitivity to companions over the samples in De Furio et al. (2019, 2022).





Results of Bayesian analysis, fitting mass ratio and orbital separation distribution models to detections and sensitivity map from the stellar sample. Alpha_q and Alpha_a are the exponent to mass ratio and orbital separation power laws and CF is the companion frequency. We find no evidence for a preferred log-normal to the separation distribution, likely due to search radius of 10-200 au.

Conclusions:

1) Our technique is sensitive to companions down to 0.025” (~ 0.5 λ/D).

2) We find an excess of wide (> 20 au) brown dwarf binaries in the ONC relative to the field (12+6/-3 % vs. 1+/-0.6%), with binding energies low enough for future dynamical disruption in the ONC.

3) We find no difference between the low-mass stellar companion frequency of the ONC and that of the field, but a significant difference relative to Taurus and Upper Sco (low-density associations) [7].

4) We find a power-law fit to the mass ratio distribution biased to higher mass ratios ($\alpha_q = 2$) for low-mass stellar primaries in the ONC, consistent with low-mass primaries (< 0.3 $M_\odot$) and inconsistent with higher mass primaries in the field.

Acknowledgments

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Citations:

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