Protobinary Candidates in OMC 2/3

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Abstract

The Orion molecular cloud is a rich and well known star forming region where all the different evolutionary stages of the star formation process can be found. It is thus an ideal region to study physical characteristics of protostellar binaries (protobinaries). Observational studies of protobinaries are important tools to get better constraints on star formation models. Yet there are few such studies. We present preliminary results of a protobinary survey in the Orion Molecular Cloud-2 (OMC-2) and OMC-3. Our data consists of mid-infrared images obtained using the European Southern Observatory VLT/VISIR, and our sample has 24 Class I protostars, previously identified via Spitzer 24 micron observations. We present at first the frequencies of protostellar multiple systems in these molecular clouds. The survey will show how many protobinary or multiple systems form in these clouds, and if these frequencies are comparable to that of other similarly observed star forming regions. Another aim of the survey is to measure the separations of the protostars in these binary or multiple systems. We also derive the mass ratios of the protostars. Comparison of these results to other similar surveys might reveal some major initial conditions necessary for the formation of binary systems. The observed parameters will help constrain star formation models, and they will shed some light on how the stellar initial mass function may be assembled from a molecular cloud core mass function.

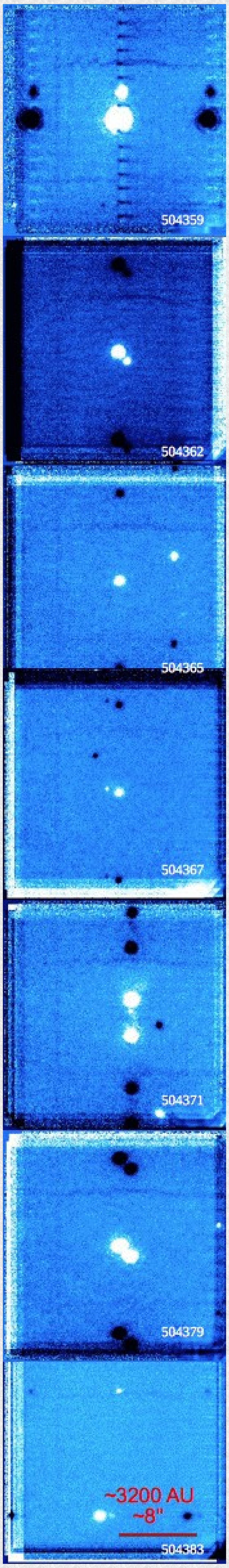

Fig. 1: ESO/VISIR N-band imaging of protostars.

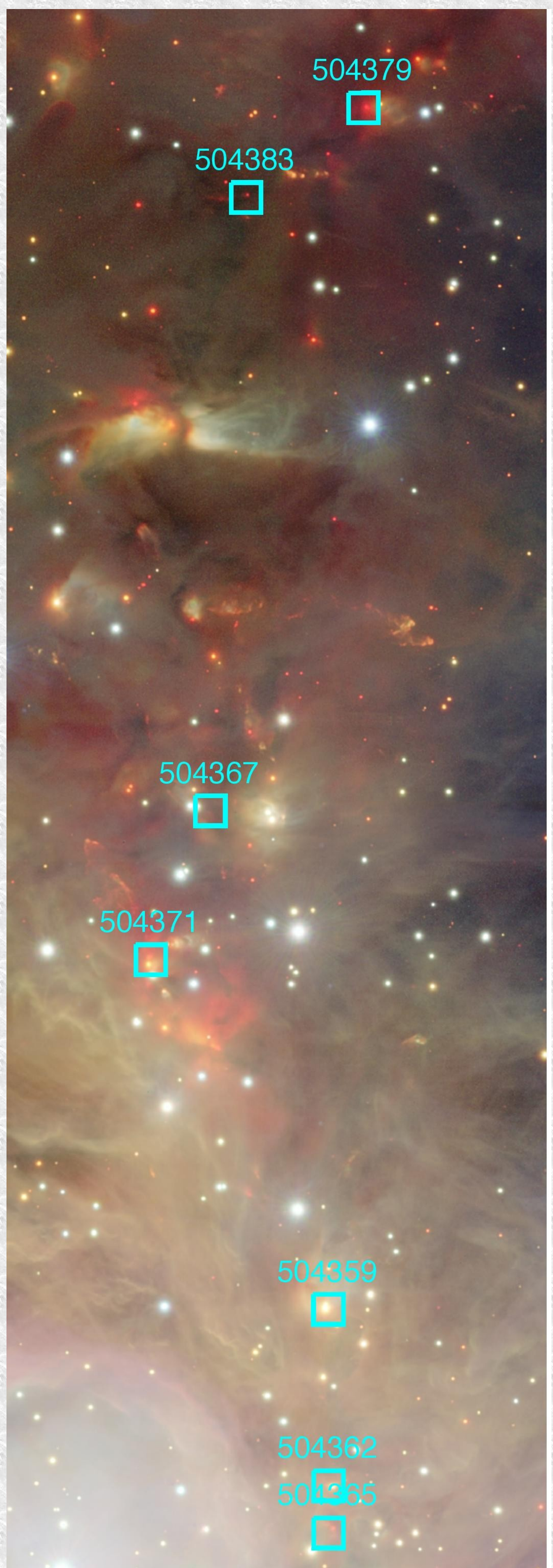

Fig. 2: ESO/VISTA JHKs image of the OMC-1 to OMC-3 regions. The green boxes mark the ESO/VISIR observations.

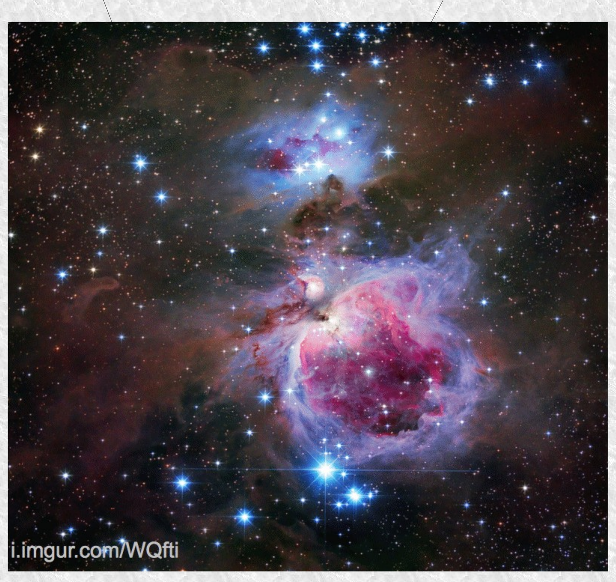

Fig. 3: Optical image of the Orion molecular cloud, indicating the OMC-1 to OMC-3 regions showed in Fig. 2.

Introduction

The formation process of intermediate and low-mass protostellar binaries (protobinaries) is by now still less observed and characterized. Protobinary formation is related to the evolution of the Core Mass Function (CMF - the distribution of dense, potentially star-forming, cores within a molecular cloud) which is directly related to the Initial Mass function (IMF). For the better understanding of this functions we need to determine

i) the multiplicity rate of protostars (also as a function of mass or environment)
ii) protobinary mass ratios,
iii) typical separations.

The multiplicity rate of Class I protostars is twice as high, for the same separations than the multiplicity rate of more evolved field stars.[1] The confirmation of this result could indicate that multiple systems decay very rapidly by dynamical interactions.

It has been shown that for the multiplicity rate of field stars is directly correlated to the spectral type of the star and that the multiplicity rate will decrease with the mass, but it is not yet sure if this multiplicity-mass relation is a primordial, i.e. if it already exist in the protostellar phase .[2]
Our observations should probe if the multiplicity fraction among low-mass protobinaries confirms the scenario of dynamical interaction or not.
It might also be possible that the multiplicity rate shows an environmental dependence (e.g. protostellar density, cloud temperature, and turbulence) like several studies have claimed.[3]
A protobinary survey (PROBIS) will be able to test protobinary formation models by also placing constraints on their predicted protobinary separations. Theory predicts that protobinaries have wider separations (hundreds of AU) than their main sequence counterpart (tens of AU).[4]
For our observations we have chosen 24 Class I protostars within embedded clusters of Orion Molecular Cloud 2 and 3 (OMC 2 and OMC 3). This allows us to get enough samples to draw statistically significant conclusions on protobinaries.

OMC 2 / 3 is one of the closest nearby star forming regions at ~414 pc[5]. Its filamentary structure is elongated from the north to the south[6] and has been observed by SPITZER, where many protostars were identified, including our targets at 24 micron observations.

Data

Name	A_k [mag]	Alpha_IRAC	MIPS [mag]
504379	5.56	0.77	0.57
504362	0.42	0.49	1.73
504367	0.19	0.19	1.51
504383		2.8	2.11
504383		2.35	2.4

Table 1: VISIR data matched with SPITZER data

Within the OMC 2 /3 we selected several targets SPITZER[7] previously identified as protostars for our PROBIS survey.

This region was observed in the mid-IR by using the European Southern Observatory (ESO) VLT/VISIR. The data was reduced with the ESO VISIR pipeline (see Table 1).

Motivation

- Understand the underlying mechanism for protobinary formation.
- Quantify multiplicity rate at the early stages of star formation, to also understand how these systems evolve and disrupt.
- The protostellar multiplicity function is an important part of the bridge between the core mass function and the initial stellar mass function.

Preliminary Results

From the 24 Class I targets 7 (39.16 %) show a certain multiplicity.
Except from one frame, 504362, all hint a third companion on the frames. Some just show the negative of the possible third partner, in some frames the third partner is very near the edge of the frame, so this is not a definite partner. So there were just 2 measurable third companions, while the rest stays unassertive.
As predicted the results show that the separations of these young protobinaries are very wide (456.51- 4563.03 AU).

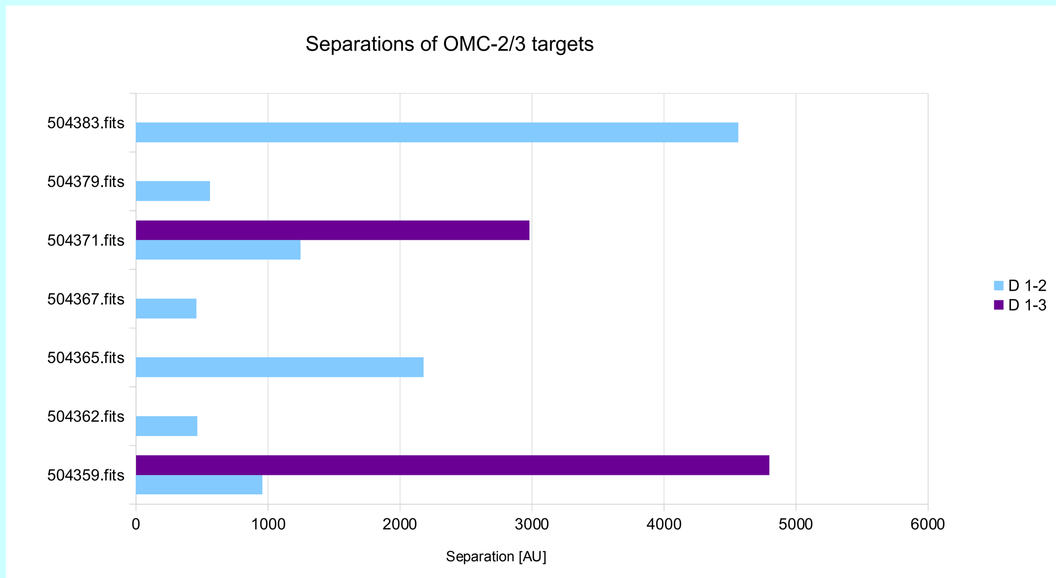

Fig.4.: Separations of the optical protobinaries (blue) and a potentially third companion (violette).

Target	Separation [AU]
504359	957.48
504362	463.68
504365	2179.04
504367	456.51
504371	1245.94
504379	559.11
504383	4563.03

Table 2: The calculated protobinary separations of the objects within OMC 2 /3.

Conclusion

- The objects previously identified by Spitzer as *single* protostars are identified as candidate multiple systems by our ESO/VISIR analysis.
- Within a selection of 24 protostars we found that 7 are candidate multiple systems, of which 6 could be triple systems.
- The separations between these sources, combined with their young evolutionary stage makes these candidate multiple systems very likely, and not just random pairings of sources.
- It is as yet unclear if the most typical mass ratio of protostellar multiple systems is 1.
- These are preliminary results, and part of a larger sample that includes other sources in Orion and other star forming regions, so stay tuned!

1) Goodwin et al. 2007, Protostars and Planets V, 133; Duchêne et al. 2007, PPV, 379. 2) Lada 2006, ApJL. 640,63. 3) Reipurth & Zinnecker 1993, A&A, 278, 81; Köhler & Leinert 1998, A&A, 331, 997. 4) Goodwin, Whitworth & Ward-Thopson 2004, A&A, 414, 633. 5) Menten et al. 2007, A&A, 474, 515; Hirota et al. 2007, PASJ. 59, 897. 6) Peterson & Megeath 2008, Handbook of Star Formation Regions, Vol. 1, 590; 7) Megeath et al. 2012, AJ, 144, 192

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