The observed multiplicity of low-mass stars: from embedded protostars to open clusters

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Summary. The multiplicity of stars is a direct tracer of the conditions under which they form and, in particular, it provides constraints on the modes of fragmentation for pre-stellar cores. For several years, we and other groups have conducted systematic surveys for the multiplicity of solar-like and lower-mass stars in nearby young open clusters (a few to a few hundred Myr) to investigate the impact of environmental conditions and/or dynamical processes. These surveys have led to the conclusion that the multiplicity of low mass stars is established by an age of a few million years at most. They have left open, however, the possibility that significant changes occur in the earlier, more embedded phases of protostellar evolution. We have recently started a statistical survey for multiplicity among embedded protostars in order to probe such a possibility. In this contribution, we summarize both types of surveys, i.e., the multiplicity of low-mass stars in young open clusters and that of embedded protostars. Using direct and high-angular resolution imaging, tens of companions have been discovered, leading to statistically significant multiplicity rates that can be compared with the predictions of (multiple) star formation models.

1 Introduction

Multiple systems result from the fragmentation of low-mass molecular cores, a process that occurs for virtually all cores. Studying the statistical properties of multiple systems can therefore provide important clues regarding the physics of this process. For many years now, numerical simulations have attempted to describe the entire sequence of collapse and fragmentation of a molecular core. Unfortunately, this numerical approach is a daunting task in large parts, because of the huge dynamic ranges in density, temperature and relevant timescales required to follow the entire process. For a long time, simplified simulations had to be performed: use of 2-dimensional calculations; impossibility to deal simultaneously with rotation, magnetic field, turbulence and viscosity; calculations halted at the opacity limit without following through until the formation of dense star-like objects, etc. These first simulations were nonetheless highly informative, proving among other things that many physical effects could lead to cloud fragmentation, hinting towards the possibility of a high frequency of multiple systems, and suggesting that the final properties of multiple systems (frequency, distribution of orbital elements) could strongly depend on the physical conditions reigning in the pre-collapse core. In the last few years, new efforts have led to the first simulations of the collapse of entire cores all the way to the formation of disk-surrounded pre-main sequence stars (Bate et al. 2003; Delgado-Donate et al. 2004; Goodwin et al. 2004). With "realistic" initial conditions, these simulations have led to the conclusion that, somewhat independently of the initial conditions, each core would fragment into many objects, typically as many as there are Jeans masses in the core. Most of these objects are then scattered away and ejected as single stars due to the strong dynamical interactions occurring in the center of the cores. The predicted average multiplicity rates are relatively low, though with a strong dependence on stellar mass. These are excellent predictions to confront with observations. The existence of young, unstable several-bodies systems is another prediction that could be tested by imaging young stellar objects with high-angular resolution devices, for instance.

It is now a well-established fact that binaries and higher-order multiple systems are prevalent among field stars of all masses. Duquennoy & Mayor (1991) conducted the most complete multiplicity survey for field stars to date, focusing on solar-type stars and determining an average companion star fraction (number of companions per number of primaries) of $61 \pm 3\,\%$ and a $\sim$10:1 binary:triple ratio. Tokovinin (2004), focusing on previously known binaries, identified additional, usually faint and distant visual, companions leading to a substantially revised 4:1 binary:triple ratio and a slightly higher total companion star fraction. The occurrence of stellar companions in lower mass Main Sequence stars is somewhat lower, especially at separations beyond $\sim$ 10 AU (Delfosse et al., in prep.). More surprising was the discovery in the early 1990s that pre-main sequence solar-type may stars host even more companions. Systematic surveys of Myr-old T Tauri stars in several well-known star forming regions, such as the Taurus-Auriga molecular cloud, discovered almost twice as many visual companions as were expected from the field star population, opening a long standing debate regarding the origin of the discrepancy (see discussion in Duchêne 1999). The fact that the Orion Trapezium low-mass star population showed a "normal" fraction, i.e., field-like, of multiple systems further complicated the situation. Should the Taurus-Auriga or Orion populations be considered exceptions to an almost universal behavior or is it a clear evidence that the fragmentation of pre-stellar cores really depend on environment conditions?

Clearly, the observed properties of ~ 1 Myr-old young multiple stars vary from cloud to cloud, but ten years ago, it was not possible to single out only one scenario that could account for all observations. For instance, Durisen & Sterzik (1994) argued that the range of multiplicity rates observed in different star-forming regions could be accounted for by a difference in initial gas temperature between giant molecular clouds, such as Orion, and smaller clouds, such as Taurus-Auriga. On the other hand, Kroupa (1995) explored the possibility that fragmentation produces a universal population of so-called primordial[1] multiple systems that then could evolve differently based on the environment in which they are. For instance, Kroupa et al. (1999) showed that a single model, in which all stars form as binaries could account simultaneously for the observed multiplicity rate for the low-mass star population in the Taurus-Auriga and Orion clouds as well as in the 100 Myr-old Pleiades open cluster. In this model, the frequent direct system-system interactions during the early stages of the cluster evolution resulted in the disruption of many low binding energy wide systems, naturally explaining the difference between clusters and loose associations.

Among all types of multiple systems, binaries are by far the most frequent. In field solar-type stars, triple and higher-order multiple are 4 to 10 times less frequent than binaries; a somewhat lower ratio seems to apply to T Tauri stars although binaries may still represent the dominant multiplicity mode (Koresko 2002; contribution by Correia et al. in this volume). Being able to explain the (high) frequency of binary systems among low-mass stars in various environments is therefore a key test of star formation theories. However, high-order multiple systems may prove even more useful as both, their formation and survival, is more sensitive to a number of processes, such as direct encounters and complex gas-stars interactions. Systems in which three stars have commensurable separations are prone to N-body dynamical instability and will likely decay into an ejected low-mass single object and a lower-order multiple. This decay, which has been suggested as a possibility for forming brown dwarfs if it happens before the end of the main gas accretion phase (Reipurth & Clarke 2001), appears to occur frequently in numerical simulations, suggesting that it may be hard for multiple systems to survive for millions or billions of years. For all these reasons, determining the properties (frequency, separations, mass ratios) of high order multiples could prove highly valuable in constraining the star formation processes. And we now start to consider the single:binary:triple:quadruple ratios as more valuable than the total number of companions to a sample of targets.

With these goals in mind, we have conducted systematic surveys to determine the frequency and properties of visual companions among low-mass young stars in a variety of environments. In particular, we first studied several open clusters of various ages to constrain the time evolution of multiplicity in clusters on timescales of 1–100 Myr and test whether the Orion population is an exception or a rather normal case. More recently, we have started probing the multiplicity of embedded protostars, which are in a much earlier phase than the previously-studied T Tauri stars, thereby probing the evolution of multiplicity on timescales of 0.1–1 Myr. In the following, we first present our survey of open clusters (Sect. 2) and of embedded protostars (Sect. 3). We then compare the observational results with other multiplicity surveys and with predictions of numerical models to place constraints on the star formation process (Sect. 4).

[1]The term “initial” would actually be more appropriate.

2 Multiplicity in young open clusters

The multiplicity of low-mass members of young open clusters was extensively studied by us (Bouvier et al. 1997, 2001; Duchêne et al. 1999) and by another group (Patience et al. 1998, 2002). The clusters that were surveyed are the following: IC 348 ($\sim$2 Myr), α Perseus ($\sim$90 Myr), the Pleiades ($\sim$125 Myr), M 34 ($\sim$220 Myr), the Hyades ($\sim$600 Myr) and Praesepe ($\sim$700 Myr). Note that in the case of IC 348, a significant age spread has been demonstrated in the low-mass population and only the average age is used here. All clusters are located within 320 pc of the Sun, favoring the detection of close companions, around the 30 AU peak of the separation distribution in Main Sequence binary systems. Depending on observing constraints, the samples that were surveyed encompassed slightly different mass ranges. Only solar-like members were studied in α Perseus, the Pleiades and Praesepe clusters, whereas a $\sim$0.5–2 $M_\odot$ mass range was probed in the Hyades, for instance. In IC 348, which is young enough that most targets were in their pre-main sequence phase, masses are less accurately known; all 0.1–2 $M_\odot$ members that were bright enough to be observed were targeted.

Altogether, a total of about 730 objects were targeted with near-infrared high angular resolution devices (adaptive optics and speckle interferometry), leading to well over a hundred new companions being discovered and to robust estimates of the statistical properties of multiple stars. Typically, speckle interferometry allows detection of tighter companions, even below the diffraction limit of a telescope, whereas adaptive optics provides a larger dynamic range and therefore a good sensitivity for very faint companions; they are therefore complementary techniques. Because of the limited field-of-view of the instruments used in these surveys, an upper limit of a few to 10 arcseconds on the multiple system projected separations was considered and unrelated background companions were excluded through their near-infrared colors and, in the case of IC 348, of their extreme faintness. Even though future analyses may reveal a few background stars that were not excluded in these surveys, these are unlikely to affect significantly our statistical results.

All clusters yielded remarkably similar results in terms of multiplicity. The raw detection rate for companions is $\sim$20 % for all clusters over almost two decades in projected separations, typically 30–1500 AU. Once completeness corrections are applied to account for tight faint companions that are difficult to detect, this implies a typical companion star fraction, i.e. number of companion per target, of 25–30 %. Within a few percent, this is equal to the fraction expected for Main Sequence solar-type stars as determined by Duquennoy & Mayor (1991) in the same separation range and, consequently, a factor of two lower than what is observed for T Tauri stars in Taurus-Auriga, for instance. The lowest fraction observed, in IC 348, is on order $\sim$20 %, only a few percent lower than solar-type field stars but this is consistent with the fact that a significant fraction of that sample consists of low-mass stars

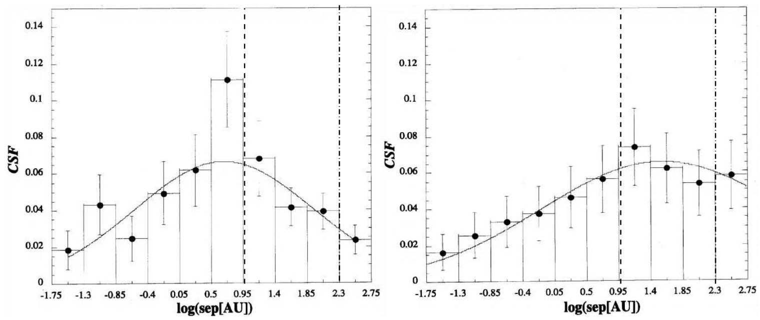

Fig. 1. The projected separation distribution of companions to low-mass stars for a combination of several open clusters (*left*) and for field stars (*right*); adapted from Patience et al. (2002). A Gaussian fit to both distribution is also plotted. Note the relative deficit of companions in clusters beyond ~ 200 AU (dot-dashed lines) whereas the cluster surveys are typically complete down to ~ 10 AU (dashed lines).

($< 0.5\,M_\odot$) for which the companion star fraction is somewhat lower in the field, especially for wide companions.

The separations of the multiple systems detected in the course of these surveys sample the entire range that was probed, from a few AUs to up to 3000 AU in some clusters. In logarithmic bins, the distribution increase towards small separations, in a trend that agrees nicely with that observed for solar-type field binaries (see Fig. 1). There is marginal evidence for a slightly lower proportion of the widest binaries probed in these surveys, i.e., for projected separation beyond ~ 200 AU. This apparent deficit is not significant in any single cluster but appears in all clusters, making it a possibly significant clue for the formation and early evolution of low-mass multiple systems.

For all clusters but IC 348, the mass of the companions can be inferred from their brightness since they are already on the zero-age Main Sequence. In IC 348, the near-infrared brightness ratio of binary systems was converted into a mass ratio assuming an average mass-luminosity relationship appropriate for the age of the cluster. While near-infrared excesses induced by dusty circumstellar disks may lead to misestimates in some systems, this should not affect the entire sample, leading to robust statistical results. The distribution of mass ratios inferred for all clusters is slowly rising towards low values ($q < 0.5$), as observed for wide companions in Main Sequence solar-type binaries (Duquennoy & Mayor 1991). It must be noted that in IC 348, companions much less massive than the brown dwarf limit could have been easily detected; yet, none was found (Duchêne et al. 1999). This is reminiscent of the observed paucity of brown dwarfs in wide orbits around stellar objects, a possible consequence of the low binding energy that such systems would have.

The detection rate of triple and higher-order multiple systems is small, on order 1 % or so. However, there is a clear detection bias against triple systems in these surveys. Broadly speaking, binary systems span rather evenly the entire separation range from contact binaries to 10^6 yr orbital periods, and roughly half of them are located in the separation range probed by the imaging surveys presented here. In triple and higher order systems, however, three-body interactions play an important role and, in order to remain stable for millions of years, the systems must be hierarchical. Typically, a factor of at least 10 between the inner and outer orbital periods is required. Therefore, triple systems that have a companion at a separation of, say, 100 AU must have their third component either too close or too wide to be detected in these surveys. At this point, it is almost impossible to interpret the observed frequency of multiple systems other than to say that their frequency in open clusters is not in excess of what is found among field stars.

An interesting point to note is the fact that the multiple systems in IC 348, the youngest cluster in our sample, are as frequent as among field stars, and not higher. The age of IC 348 is comparable to that of the pre-main sequence populations that were studied in the early 90s and its low-mass members are T Tauri stars. This clearly shows that the Trapezium cluster cannot be considered an exception among all other star-forming regions. Rather, it suggests that all few million years-old clusters have a substantially lower companion star fraction than other loose star-forming regions such as Taurus-Auriga. This leaves both scenarios presented in Sect. 1 (sensitivity to initial conditions on one hand and universal primordial population combined with dynamical interactions/disruptions in dense clusters) open, with the only new constraint that, if dynamical interactions in clusters are at play, they must occur on a timescale shorter than $\sim$1 Myr.

3 Multiplicity among embedded protostars

Since the observations of stellar populations that are a few Myr-old could not discriminate between the two main scenarii put forward several years ago, it became clear that the solution may come from the observations of even younger populations. Therefore, the study of low-mass star multiplicity shifted in recent years towards the first Myr of stellar evolution, before the T Tauri phase itself. The youngest such systems, Class 0 protostars that are only $\sim 10^4$ yrs-old, have most of their mass in the envelope and emit principally in the far-infrared and radio domains. Class I sources are in an intermediate evolutionary stage and are increasingly bright at longer infrared wavelengths. High-angular resolution observations of these objects, which are necessary to probe their multiplicity, were not feasible until a few years ago, but recent surveys have taken advantage of the newest generation of instruments. In this section, we present results from various surveys for embedded multiple systems, conducted in the radio and near-infrared regimes.

A first systematic survey was conducted by Looney et al. (2000) with interferometric observations in the millimeter regime, where they were sensitive to the thermal emission from the cold dust surrounding embedded young stellar objects. Concentrating on the 6 Class 0 and 2 Class I sources in their sample (which also included some T Tauri stars), they found that every single protostar had at least one additional companion within their field of view. However, because of the broad ranges of angular separations probed and of distances to the targets, many of these systems had projected separations of several to ten thousand AUs. This implies that some of these systems are likely to be unbound and, in any case, that this survey cannot easily be compared to previous multiplicity surveys which focused on tighter systems. Using a 2000 AU upper limit for projected separation, their surveys was composed of 16 independent systems, including 3 binaries and no higher order multiples. The absence of triple systems can be understood given the small range of separations probed by these observations and, within that range, a $\sim$ 20% companion star fraction should be considered quite substantial. Despite the small number statistics associated to this study that precludes any meaningful comparison to other surveys, this work confirmed that binary (and possibly multiple systems) are prevalent among embedded protostars.

Focusing on a sample of 14 embedded young stellar objects that drive giant molecular outflows (mostly embedded protostars) and gathering near-infrared and radio high-angular resolution data, Reipurth (2000) found an observed binary frequency of order 80%, the highest ever measured in a population of young stars. The projected separations ranged from less than 10 to several thousand AUs and, due to the variety of distance and instrumental technique involved, it is difficult to extract a multiplicity rate that could be compared to other surveys. Yet, the observed multiplicity was so high that it led Reipurth to argue that the presence of giant outflows is directly related to multiplicity, possibly through the dynamical decay of unstable high-order multiples. If true, this would imply, however, that the high multiplicity rate he estimated is actually an overestimate of the intrinsic rate for all embedded sources. Following on this idea, Reipurth et al. (2002; 2004) obtained centimeter-wave high-angular resolution maps of a sample of 21 young stellar objects, mostly Class I sources, and observed a well-defined 33% multiplicity rate over the 0.5–12" angular separation range (distances ranged from 140 to 800 pc). Among these sources, 4 out of 7 objects that drive giant outflows were found to be multiples, a marginally higher rate. Overall, the multiplicity rate of embedded sources is in good agreement with that of T Tauri stars in star-forming regions such as Taurus-Auriga and Ophiuchus.

In a complementary approach, Haisch et al. (2002; 2004) and Duchêne et al. (2004) conducted direct near-infrared imaging surveys of Class I sources in nearby star-forming regions. A total of 119 protostars in the Perseus, Chamaeleon, Serpens, Ophiuchus and Taurus-Auriga have been targeted; in the latter two clouds, the surveys are essentially complete. The importance of these new surveys resides in their larger and better-defined samples, allowing robust statistical analyses. The observed multiplicity rate is again in the 20–30% range, in agreement with the radio surveys described above over

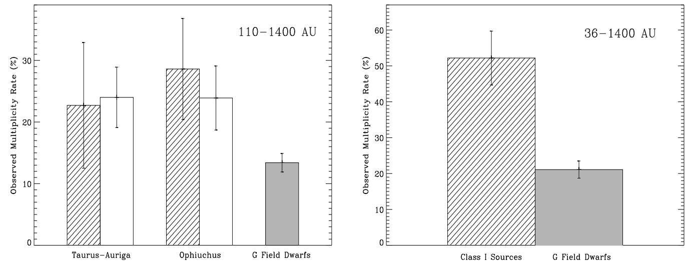

Fig. 2. *Left:* The observed frequency of visual companions for Class I protostars from direct imaging surveys (hatched histograms) and T Tauri stars (empty histograms) in the Taurus and Ophiuchus star-forming regions, from Duchêne et al. (2004). *Right:* Similar histogram after the higher angular resolution surveys, merging all star-forming regions together.

similar separation ranges. The observed companion frequency of embedded protostars is also in agreement with surveys of optically-detected T Tauri stars in the Taurus and Ophiuchus clouds (see Fig. 2). In addition to these surveys, we have recently obtained adaptive optics images of a subsample of 44 Class I sources in order to probe a broader range of projected separations for these objects (Duchêne et al., in prep.). With such observations, we can both increase significantly the number of known companions and detect hierarchical multiple systems that were not present in the direct imaging surveys. In the 36–1400 AU separation range, and limiting ourselves to flux ratios not larger than $\Delta K = 4$ magnitudes, we find a 52.2±7.5% companion star fraction for Class I sources. This is about two and a half times higher than the multiplicity rate of solar-type field stars (see Fig. 2) and it is at least as high as the highest rate observed in a population of T Tauri stars.

Of particular interest is the finding that the clustered Perseus and Orion (L1641) populations of embedded protostars show the same multiplicity rates as the Taurus-Auriga and Ophiuchus populations. This is a different behavior than what is observed for T Tauri stars, suggesting that there is indeed a substantial decrease of the multiplicity rate in dense clusters between the embedded protostar and revealed T Tauri phases. Indeed, Duchêne et al. (2004) found evidence that protostars in Taurus-Auriga and Ophiuchus that still possess a substantial envelope revealed by millimeter mapping had a somewhat higher companion star fraction than those who do not. This may be the first direct evidence that the frequency of multiple systems actually evolves during the first million year, possibly as a result of direct system-system interactions in clusters, as suggested by Kroupa (1995).

The observed distribution of projected separations is consistent with that observed for somewhat older T Tauri stars, although small number statistics prevent definitive conclusions in this respect. Mass ratios cannot be inferred from a single near-infrared flux ratio given the complex nature of protostars:

ongoing accretion and the details of their opaque environment can result in a wide range of near-infrared fluxes almost independently of the system's total mass. However, a few interesting systems were found with extremely large flux ratios (up to $\Delta K = 6$ magnitudes). Given the rather low luminosities of the primaries, these companions could be very low-mass companions, potentially proto-brown dwarfs. Only spectroscopic follow-up, which is already under way for some systems, will help determining the exact nature of these objects but they represent a potentially crucial population for our understanding of the formation and early evolution of brown dwarfs.

The observed frequency of triple systems (there are no higher order systems), about 14% in the 36–1400 AU range, is relatively high, yielding an observed binary:triple ratio on order 4:1 even though we have sampled a somewhat limited range of projected separations. Extrapolating this ratio to account for much tighter and wider systems, one could expect a $\sim$30% frequency of high order multiple systems, much higher than observed among field stars, for which the binary:triple ratio is merely equal to our *observed* ratio. The proportion of triple and higher-order systems among T Tauri stars is also very high, however, and this may simply reveal the existence of unstable systems yet to be disrupted over longer timescales. Most of the triple systems we have found (5 out of 6) are hierarchical with a ratio of projected separations of at least a factor of 4.7 and therefore a ratio of orbital periods larger than $\sim$10; they are therefore likely to be long-term stable.

4 Implications for the star formation process

Overall, the multiplicity surveys summarized here reveal a relatively clear picture of the early evolution of multiple systems. First of all, it is now clear that low-mass stars in all open clusters have indistinguishable multiplicity properties from field stars, with the possible exception of the frequency of the systems with separations of several hundred AUs. The fact that young cluster and field populations of multiple systems are so similar should not be considered a surprise, since it is believed that most stars form in such clusters (but see Adams & Myers 2001). Still, this independent confirmation is reassuring in that multiple systems can indeed be considered as good tracers of the evolution of stellar population. In addition, it confirms that most multiple systems are already settled by the age of these clusters and little, if any, evolution occurs beyond a few million years. From a dynamical standpoint, this was to be expected, as clusters are usually already relaxed on the large scale by that age and individual unstable multiple systems decay on a much shorter timescale. We note, however, that some of the least dense cluster-like populations of Myr-old stars, like the optically-detected young stars in ρ Ophiuchus, possess a high multiplicity rate, similar to Taurus. This can be interpreted as evidence that the cluster is not dynamically evolved yet, i.e., its crossing time is still longer than its current age, so that most stars have not yet interacted with other members of the cloud. One therefore predicts a significant decrease of the multiplicity rate in this cloud over the next few million years, although we will not be able to test this hypothesis.

Moving in towards younger sources, observations suggest that only few unstable systems decay over the $\sim 10^5$–10^6 yrs timescale probed between Class I protostars and T Tauri stars in loose associations. It is possible that many systems have decayed much earlier on ($<< 10^5$ yrs), but it must be noted that the limited number of isolated single stars is so limited that it is hard to imagine that each pre-stellar core led to the formation of > 4–5 stars. This reasoning has led Goodwin & Kroupa (2005) to conclude that most cores fragment in only 2 or 3 stars. This seems to contradict the results of numerical simulations of turbulent core fragmentation, which tend to form many stars per core. We note, however, that if the strength of the turbulent velocity field is significantly reduced, fragmentation becomes much less efficient, leading to a smaller number of stars formed from a single core.

Another observational-established fact is the moderate mass dependence of the multiplicity rates between $\sim 0.1 M_\odot$ and $\sim 1 M_\odot$, for both main sequence and T Tauri populations. Numerical simulations of turbulent fragmentation predict much stronger mass-dependencies as a consequence of the violent system-system interactions within a single core. The formation and survival of a significant population of low-binding energy systems probably indicates that fragmentation occurs in a much quieter way. It is still too early to use the observed properties of young multiple systems to derive physical parameters of the pre-collapse cores, such as their total mass or turbulent strength (contribution by Delgado-Donate et al. in this volume). A more stringent constraint on the model may eventually come from multiplicity surveys among young brown dwarfs that are already underway.

Possibly the most important results from the multiplicity surveys of embedded protostars is the absence of significant differences between star-forming regions, even though moderate and dense clusters as well as loose associations have been studied. This seems to indicate that the core fragmentation process proceeds to a rather universal set of properties for wide multiple systems despite the wide range of physical properties probed. Most likely, this indicates that the large scale properties of the cloud (such as its total mass or initial gas temperature, before the collapse of the entire cloud) play almost no role on the fragmentation itself, which could be influenced by local properties (e.g., gas temperature just before fragmentation of individual cores). In turn, these properties could be more uniform than expected, even though pre-stellar cores are known to be denser and more compact in cluster-like environments than in loose associations (Motte & André 2001). In any case, this finding is well in line with the assumption of Kroupa's models, i.e., a universal initial population of multiple systems.

Taking all observations into account, we propose the following scenario for the formation and early evolution of low-mass stars; this scenario is illustrated

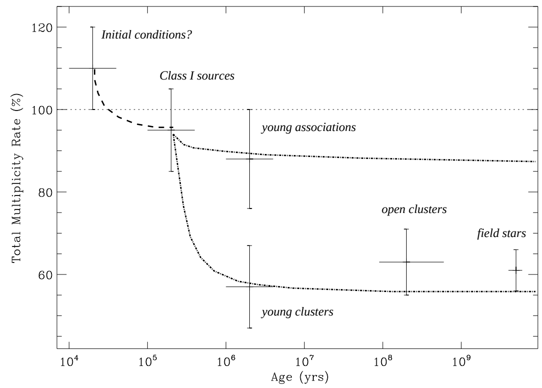

Fig. 3. Time evolution of the *total* multiplicity frequency (extrapolated from the number of visual companions) as a function of time. Horizontal errorbars represent the range of objects observed in each type of populations. The rate for the youngest sources in this plot has *not* been observed so far; we simply estimate it to be somewhat higher than that of Class I sources based on the limited number of ejected single stars. The dashed curve represents the decay of initially unstable multiple systems and the dot-dashed curve the decay due to system-system encounters in stellar populations; these are much stronger in clusters (lower curve) than in loose associations (upper curve), accounting for the dual multiplicity mode around 1 Myr.

in Fig. 3. First of all, most low-mass (a few $M_\odot$ at most) pre-stellar cores fragment into 2–4 objects, resulting in a high frequency of both binaries and higher order multiple systems with an overall proportion of 1 or slightly more companion per primary. Over a timescale of $\sim 10^4$ yrs, the multiple systems that are internally unstable decay, thus freeing a few single stars and thereby reducing somewhat the total multiplicity rate (through both the loss of a companion and the addition of a new single primary). Then, each core may interact with its neighbors, at least in dense enough star-forming regions, resulting in a new decrease of the multiplicity frequency on a time scale of a few 10^5 yrs. In loose star-forming regions, this effect is barely noticeable, but it can remove up to 50% of all companions in clusters. After about 1 Myr, the evolution is almost over, as dense clusters have already been dynamically stirred up whereas associations are already almost dissipated in the field. Only intermediate clusters, such as Ophiuchus, may decay on a timescale of several Myr. Finally, field stars are the sum of all stars, i.e., some weighted average of the various star formation channels. While this scenario is entirely consistent with current observations, it still needs confirmation, especially at the youngest ages and, as far as understanding the initial conditions, the universality of the properties of multiple systems still needs to be explained.

As a final thought, we note that the frequency of high-order multiple systems (triples, quadruples, ...) among low-mass embedded protostars has not yet been established with a sufficient statistical significance to be conclusive. However, it seems plausible that they are more frequent than among field stars which could be due to the existence of unstable systems early on. If this is correct, then the disruption of unstable systems should be a rather common phenomenon that could occur on a timescale on order a few 10^4 yrs, so that it is not so unlikely that such events could be witnessed among the youngest systems. While recent claims of dynamical ejection in the T Tau triple system need further monitoring (and may well be wrong), it is important to keep track of proper motion and radial velocities within known multiple systems and for single stars in the vicinity of known multiple systems. In any case, we reiterate the importance of understanding not only the total number of companions in a given sample, but the relative frequency of single, binary, triple, quadruples, ..., systems, as these carry crucial information regarding the processes that occur during the first ~ 1 Myr of their evolution.

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