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The Gaia-ESO Survey: kinematical and dynamical study of four young open clusters

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Abstract. The study of the origin and the fate of young stellar clusters is one of the major argument in the modern stellar astrophysics. In order to understand the origin of star clusters and their evolution into bound or unbound systems, several models have been proposed. A key point to test these theoretical models is to study the kinematical and dynamical properties over a wide range of ages and masses. A fundamental role to understand the early evolution of these objects is the observations and study of open clusters with age between 10 and 100 Myr, since they have dispersed the gas of the giant molecular clouds from which they have formed but have not been affected by tidal effects due to outer gravitational field that occur on longer timescale. Thanks to *Gaia*-ESO Survey spectroscopic data, I analyze the kinematical properties and characterize the dynamical state of four young (30 – 50 Myr) open clusters. With several spectroscopic tracers, for each cluster I derived a list of candidate members and the kinematical properties in order to investigate their dynamical state. I found that three out of four clusters are unbound and probably they will dissipate in the field.

1. Introduction

The majority of stars form in associations and clusters inside giant molecular clouds. The vast majority of clusters dissipate within 10 – 100 Myr and more than 90% of the cluster population disperses in the Galactic field (e.g. Lada & Lada 2003; Goodwin & Bastian 2006). Several models have been proposed to understand the evolution of a cluster in a bound or unbound state and the processes that lead to their dissolution. On one hand, models predict that after cluster formation the primordial gas is swept away due to stellar feedback and cluster rapidly dissipate (e.g. Kroupa et al. 2001; Goodwin & Bastian 2006; Baumgardt & Kroupa 2007). After gas dispersion clusters should be found in a supervirial state. On the other hand, other models suggest that stellar feedback is not fundamental for the dispersion of cluster, that is guided by two-body interactions (e.g. Bressert et al. 2010; Kruijssen et al. 2012). In order to have a full understanding on the origin and evolution of clusters, study at different evolutionary stage of the kinematical properties of their stars is fundamental. In this context, the *Gaia*-ESO Survey (GES, Gilmore et al. 2012; Randich et al. 2013) is a large spectroscopic public survey of all components of Galaxy and one of its goal is to investigate the dynamical evolution of young clusters through the derived stellar parameters with its observations. In this work, we study the dynamical state of four young (30 – 50 Myr) open cluster: IC2602, IC2391, IC4665 and NGC2547.

2. Sample and analysis

For each cluster, the selection method of GES observations is unbiased and this implies that the observed sample are contaminated by the field stars. In order to exclude these stars (giants and dwarfs non members), I filter out the secure non members using the gravity index γ (Damiani et al. 2014) and the equivalent width of the lithium line at 6708 Å derived by the GES consortium and released in iDR4.

Through the radial velocity of the stars selected as candidate members, I determine the intrinsic radial velocity dispersion (σ_c) of each clusters and the probability of each stars to be a member. The radial velocity distribution is modeled using the maximum likelihood technique developed by Cottaar et al. (2012), that take into account the presence of binaries and the errors on radial velocities. Finally, I determine the mass of each star from Hertzsprung-Russel diagram. The masses of stars with a probability to be a member greater than 0.8 are used to determine the total cluster mass (M_{tot}). This mass is corrected for completeness and binary.

3. Results and conclusion

The main goal of this work is to probe the dynamical state of these young clusters. With the properties obtained using the GES data, I calculate the radial velocity dispersion at the virial equilibrium, σ_{vir}, defined as

$$\sigma_{vir} = \sqrt{\frac{M_{tot}\ G}{\eta\ r_{hm}}} \qquad (1)$$

where η is a dimensionless constant, which is approximately equal to 10 for a Plummer sphere profile (e.g. Portegies Zwart et al. 2010) and r_{hm} is the half mass radius found starting from M_{tot}. Mass and radial velocity dispersions for clusters are listed in Table 1. All the radial velocity dispersions obtained from the GES sample are greater than σ_{vir}, with the exception of IC4665 for which we found an upper limit. The value of σ_{vir} may be underestimated due to either a lower value of η (Fleck et al. 2005; Portegies Zwart et al. 2010) or a lower value of r_{hm} in the case of mass segregation. However, the discrepancy between the derived radial velocity dispersion and those at the virial equilibrium is about a factor ~ 3 for all the three clusters and not even considering the errors on σ_c the two dispersions might be in agreement. Therefore, fit results seems to be solid and, from the comparison of the two dispersions, three out of four clusters are "super-virial" and likely dissipating. This is consistent with the "infant mortality" scenario (e.g. Kroupa et al. 2001; Goodwin & Bastian 2006), which suggests that clusters became unbound after "feedback" from massive stars swept out the gas.

Table 1. Properties of selected clusters.

Cluster	M_{tot} ($M_\odot$)	σ_c (km s^{-1})	σ_{vir} (km s^{-1})
IC 2602	~ 140	0.60 ± 0.20	~ 0.17
IC 2391	~ 70	0.53 ± 0.17	~ 0.15
IC 4665	~ 71	< 0.5	~ 0.12
NGC 2547	~ 136	0.63 ± 0.09	~ 0.21

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