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Investigation on fundamental plane of open clusters

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Abstract. The fundamental plane (FP) is the relation between the surface brightness (I), velocity dispersion (σ) and radius (R). The tilt of FP from the virial plane ($R = \sigma^2\, I$) not only tells the dynamical states of the system but also its formation and evolution. We motivate to looking for an FP in Galactic open clusters (OCs). To form a sample of OCs, we access the most recent DR 14 data from the SDSS/APOGEE2 and the Gaia-ESO survey. Membership of stars is determined via radial velocity and metallicity, plus star's location in the color-magnitude diagram. Besides the velocity dispersion (σ_{rv}) obtained from SDSS/APOGEE2 & Gaia-ESO, the average surface brightness (I_{K_s}), and apparent radii (r_2) of OCs are taken from known OC catalog. A weak relation is found: $log(r_2) \propto -0.34 * log(\sigma) - 0.08 * I_{K_s}$. An implication of this FP needs further investigation.

Keywords. (Galaxy:) open clusters and associations: general

1. Motivation

The effective radius, average surface brightness, and centralvelocity dispersion of elliptical galaxies form a two-dimensional family so called Fundamental Plane (FP) (Djorgovski & Davis 1987). The FP of elliptical galaxies is tilted from the virial plane ($R \sim \sigma^2\, I^{-1}$) significantly. For globular clusters, the FP at core radius agrees with virial plane, while it is tilted at half-light radius (Djorgovski 1995). The causes of the tilt of FP in spherical systems are mainly due to their non-constant mass-to-light ratio and non-homologous structures. To extend the FP to lower-mass dynamical system, we attempt to establish an FP among Galactic open clusters (OCs). A homogeneous kinematic data of OCs are available, thanks to the modern sky surveys: SDSS/APOGEE & Gaia-ESO.

2. Sample selection

The first step to select OCs samples consists of a crossmatch of APOGEE stars in the SDSS DR14 (Abolfathi *et al.* 2017) with the coordinates of OCs in Kharchenko *et al.* (2013) catalog. OCs having more than 10 stars within their apparent radius r_2 will remain in the sample, which is the distance from the cluster center to where cluster stellar density equal to that of the field. Totally 37 OCs are retrieved. Secondly, membership of stars is determined based on metallicity [Fe/H] and radial velocity V_R (from pipeline ASPCAP). We select a range of [Fe/H] and V_R by eyes (dashed lines in the left panels in Fig. 1) in order to exclude obvious outlier from the computation of the mean and standard deviation. All stars lying within $1\,\sigma$ both from the means of [Fe/H] and V_R are considered as possible members. Furthermore, we examine the location of possible members in the color magnitutde diagram (CMD). Stars located on top or close to

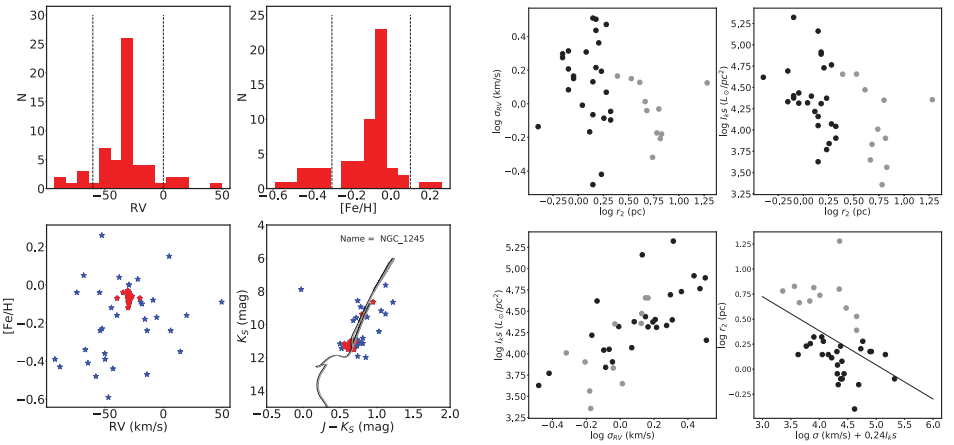

Figure 1. Left: the histograms of V_R and [Fe/H], stars within dashed lines are used in the computation of the mean value and standard deviation of each distribution; diagram of [Fe/H] vs. V_R; blue starred symbols are stars detected within r_2, red dots are selected members from the procedure in Sec. 2; the CMD of a sample cluster, black and grey curves are corrected for different reddening laws. Right: relations among velocity dispersion σ, apparent radius r_2, and K_S band average surface brightness I_{K_S} within r_2. Black dots are OCs detected in APOGEE, while grey dots Gaia-ESO. The black line is the fitted FP for the samples.

isochrones of the cluster age will be considered in the next step of analysis. Apparent radius r_2 and K_s band integrated magnitude are taken from Kharchenko *et al.* (2013, 2016). We also combined 11 OCs with membership and velocity dispersion determined from Gaia-ESO survey (Jacobson *et al.*2016) into the final OC sample.

3. Results and Discussions

As seem from the right panel in Fig. 1, velocity dispersion σ shows a very weak declining trend with apparent r_2, while average surface brightness I_{K_S} increases with σ of higher level of significance. There is no correlation between σ and I_{K_S} at all. We find an FP among our OC samples as $log(r_2) \propto -0.34 * log(\sigma) - 0.08 * I_{K_s}$ with relatively large residuals. The biggest cluster located the second furthest. Its r_2 suffers from larger uncertainty. Implication of the FP will be investigated and discussed in an coming paper.

4. Acknowledgement

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References

Abolfathi, B., Aguado, D. S., Aguilar, G., *et al.* 2017, arXiv:1707.09322
Djorgovski, S. & Davis, M. 1987, *ApJ*, 313, 59
Djorgovski, S. 1995, *ApJ*, 438, L29
Jacobson, H. R., Friel, E. D., Jílková, L., *et al.* 2016, *A&A*, 591, A37
Kharchenko, N. V., Piskunov, A. E., Schilbach, *et al.*, 2013, *A&A*, 558, A53
Kharchenko, N. V., Piskunov, A. E., Schilbach, E., Röser, S., & Scholz, R.-D. 2016, *A&A*, 585, A101

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