Letter of Intent AS4

Open Cluster Kinematics and Age Survey (OCKAS)

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Open clusters are valuable systems for the study of both stellar evolution and galaxy dynamics. By definition, the constituent stars are co-natal having formed in a localised environment with homogeneous initial chemical composition during a single star-formation event. The ages and compositions of open clusters can therefore be determined with relatively high precision. This high precision is of importance to test stellar evolution models and understand the motion of spiral arms and moving groups of stars (Vande Putte et al. 2010).

For most open clusters only basic information is known, such as position of the cluster centre, apparent size, proper motion, distance, colour excess, and age (Kharchenko et al. 2013). However, many questions concerning the evolution of open clusters still remain. These include but are not limited to: What are the internal motions of stars in a cluster? How do these motions change over time? What is the fraction of binary (or multiple) stars in clusters? How can we explain the (anti)correlations between different chemical elements in open clusters of different ages? How do clusters evaporate?

Some dedicated efforts such as the WIYN Open Cluster Study (WOCS) have already reported detailed studies of a limited number of open clusters, such as the Hyades (Maderak et al. 2013), M35 (Steinhauer & Deliyannis 2004) and NGC 6819 (Milliman et al. 2014). However, such detailed studies are reported for order tens out of hundreds of known open clusters, which prevents to draw conclusions regarding the evolution of open clusters. Additionally, for some open clusters, asteroseismic – asteroseismology is the study of the internal structures of stars through their intrinsic oscillations – data are and will become available from photometric space missions such as CoRoT (e.g. NGC 2264, NGC 6633), *Kepler* (e.g. NGC 6811, NGC 6819, NGC 6791), K2 (e.g. Hyades, M67) and Tess. These data can provide information about the masses and radii of the individual cluster stars.

With this Letter of Intent we propose a large-scale homogenous survey to study the intra-cluster dynamics of a statistically significant number of open clusters to study the chemo-dynamic evolution of these stellar associations. We foresee that this can be accomplished by way of utilizing the APOGEE spectrograph to obtain radial velocity observations for a significant fraction of stars across clusters of different ages. We aim to investigate both the central parts as well as the outskirts of the open clusters.

Using radial velocity measurements taken at different intervals -- ranging from an observation every consecutive night to once a month -- combined with proper motions and distances from Gaia as well as asteroseismology (where available) the following phenomena can be studied within each cluster:

- binarity / multiplicity of stellar objects;
- kinematics;
- stellar activity;
- stellar rotation (from activity).

Studying these processes in a large number of stars in open clusters of different ages will allow us to draw inferences regarding:

- evolution of orbital parameters of binary / multiple systems;
- evolution of intra-cluster motions;
- evaporation / disruption processes;
- gyrochronology.

In addition to the radial velocities, chemical abundances can also be derived from the APOGEE data. Homogeneous spectroscopic abundance analysis provides the opportunity to study the signatures of the cluster progenitors and test stellar nucleosynthesis predictions. Targeting clusters across a wide range of ages and locations furthermore places constraints on enrichments timescales for Galactic chemical models. In their survey of young open clusters, D'Orazi et al. (2009) identified an age – barium anticorrelation. This result raises questions concerning the predicted barium s-process yields from low-mass stars. A homogeneous abundance analysis of s-process, r-process, alpha-element and CNO nuclei in open clusters will prove valuable diagnostics of stellar evolution, mixing, nucleosynthesis as well as helping to further constrain Galactic chemical evolution.

References:
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