(Extra)galactic Stellar Aggregates

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ABSTRACT

The study of open clusters naturally introduces many advantages, because they are physically related groups of stars held together by mutual gravitational attraction that were formed at roughly the same time from one large cosmic gas and dust cloud. Their evolutionary stages range from clouds where star formation takes still place at this moment to very old aggregates with turn-off points as late as solar type stars. Therefore, they represent samples of Population I stars of constant age and comparable intrinsic chemical composition, suited for the study of processes linked with the stellar structure and evolution, and to fix lines or loci in several most important astrophysical diagrams. As a summary it can be concluded that open clusters allow to study a significant amount of astrophysical parameters and models from the global scale of the Milky Way down to processes in individual stars from the Pre-Main-Sequence to Post-AGB evolution. We therefore want to present our latest work concerning the accuracy of open cluster parameters, the search for chemically peculiar stars in galactic open clusters and the Large Magellanic Cloud, our broadband survey of open clusters, the investigation of a very young aggregate and the database for open clusters WEBDA.

The current status of open cluster parameters

Open clusters can be used to study the evolution and distribution of various star groups (e.g. chemically peculiar stars). But what about the accuracy of the presently known open clusters parameters? To answer this question, we have searched the literature for determinations of the age, distance and interstellar reddening of open clusters. For the final list, we have averaged the data of open clusters for which at least three independent estimates of the parameters are available. It contains 6437 individual estimations for 395 open clusters. This data was used to calculate the means and the respective errors.
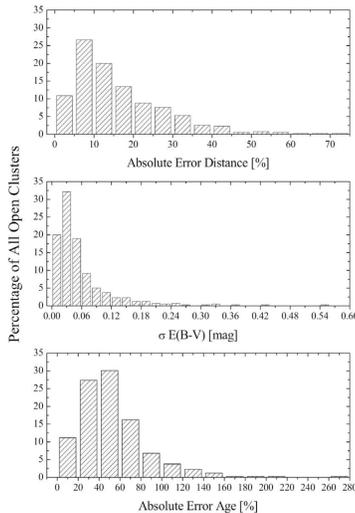
While the reddening seems to be quite accurate, the ages and distances suffer from severe uncertainties. For about 90% of all studied clusters, the error of the reddening is below 0.1 mag. For the distance we find absolute errors of less than 20% for about 80% of the aggregates. But only 11% of the investigated open clusters have errors of the ages which are less than 20%. There are extreme values of more than 200%. This calls for a homogeneous set of isochrones together with a solid fitting technique.

As last step, a set of 72 open clusters with the most accurate (in a statistical sense) errors were established. Those clusters cover a wide range of reddenings, ages as well as distances and should serve in the future as standard tablet for testing theoretical models.

The distribution of the mean absolute errors of the distance and age as well as the standard deviation of the reddening for the complete sample of 395 open clusters with more than three independent measurements from the literature. This figure summarize the current accuracy of open cluster parameters.

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The open cluster database WEBDA (http://www.univie.ac.at/webda)

WEBDA is a site devoted to observational data of stars in galactic and extragalactic open clusters. It is intended to provide a reliable image of the available data and knowledge about these objects and to offer a wide access to the existing observations. The database has been conceived to bring at one place most data that could be useful to decide upon the membership of stars and their physical characteristics, and store them with a coherent numbering scheme. It is the best starting point for many astrophysical studies involving open clusters.
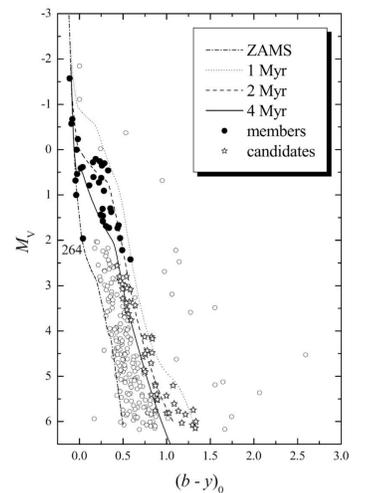
No other database exists which provides more data, about 3.5 Million measurements, for stars in open clusters. The present database offers astrometric data in the form of coordinates, rectangular positions, and proper motions, photometric data for about 20 different systems, spectroscopic data, like spectral classification, radial velocities, rotational velocities. It contains also miscellaneous types of data like membership probabilities, orbital elements of spectroscopic binaries, periods of variability for different kinds of variable stars. Lists of interesting and peculiar stars have also been compiled. Finally a whole set of bibliographic references allows every one to locate the interesting publications on his or her favorite open clusters easily. About 450 refereed publications since the year 2000 acknowledge the use of WEBDA.

Star formation in the very young open cluster NGC 6383

Young open clusters offer the opportunity to investigate star formation simultaneously for a significant number of stars from high to very low mass. Processes like accretion, mass-loss and pulsation in the presence of both local and global magnetic fields can be studied for example. The pre-main sequence (PMS) phase of stellar evolution has been extensively investigated in the last decade. With the detection of magnetic fields and the application of asteroseismic tools the early phases of the stellar evolution begin to reveal their mysteries.

We have investigated the young open cluster NGC 6383 with several photometric systems, presenting new Strömgren uvby CCD photometry for 272 stars. From this data we derive a reddening of $E(b-y)=0.21(4)$mag and a distance of 1.7(3)kpc. An upper age limit of 4Myr was determined for NGC 6383. Neither a turn-off point nor red giants have been detected.

In the M_v versus $(b-y)_0$ color-magnitude diagram, 44 probable PMS members could be traced from A to very cool M-type objects. At least 14 of them are in the NIR (2MASS) domain of classical T Tauri stars. Appropriate isochrones clearly show that members are present from 1 to 4Myr with a distinct separation from the field population at absolute magnitudes between +0.5 and +2.0mag. Five stars with a large NIR excess are unambiguously identified in a $(J-H)_0$ versus $(H-K_s)_0$ diagram.

We also report the identification of two rapidly-rotating PMS stars with angular velocities of approximately 30 to 40% of their break-up velocity. Such objects are still very rare and most important for understanding the early stages of stellar evolution, in the presence of accretion and local magnetic fields.

The color-magnitude diagram of NGC 6383.

## The peculiar star content in the Large Magellanic Cloud

The detection of magnetic chemically peculiar (CP2) stars in open clusters of extragalactic systems can give observational answers to many unsolved questions. For example, one can study the influence of different global as well local environments on the lack or presence of peculiarities. The origin of the CP2 phenomenon seems to be closely connected to the overall metallicity and global magnetic field environment. The theoretical models are still only tested by observations in the Milky Way. It is therefore essential to provide high quality observations in rather different global environments.

The tool of Δa photometry (Maitzen 1976), which takes advantage of the prominent, CP2 typical flux depression at 5200Å, is an economic way to study and to detect the necessary larger samples.

After the first detection of extragalactic CP2 objects in the Large Magellanic Cloud (Maitzen et al. 2001), the investigation continued with the work by Paunzen et al. (2005). Together with the recent investigation by Paunzen et al. (2006) the studied sample comprises the LMC clusters NGC 1866, NGC 1711, the double cluster NGC 2136/7, their surroundings and an independent LMC bulge field.

We conclude from our investigations that the occurrence of classical chemically peculiar stars is 2.2(6)% in the LMC, which is only about half of the typical value in the Milky Way. The age and mass distributions, derived by applying appropriate isochrones, do not alter from those of CP stars in galactic open clusters. This provides a valuable observational source for understanding the CP phenomenon of the upper main sequence in a different global environment than in our Milky Way.

The data reduction and analysis of a 30' field in the Small Magellanic Cloud, observed at the ESO 2.2m WFI using a comparable Δa filter combination, is in progress. The results of about 100000 objects at an even lower metallicity environment than the LMC will contribute another piece of the puzzle.
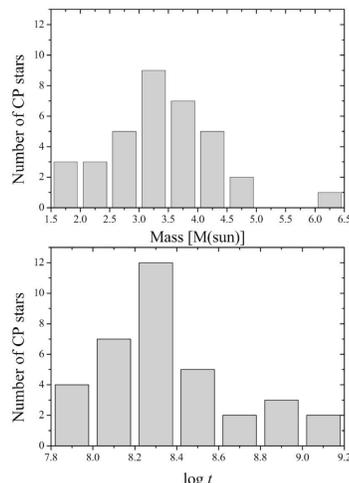
The mass and age distribution of all detected CP2 objects.

Δa & broadband survey of galactic open clusters

The continuation of our Δa survey and the search for chemically peculiar stars in galactic open clusters includes the investigation of 16 further clusters (Paunzen, Netopil et al. 2006; Netopil, Paunzen et al. 2007) lying at galactocentric distances RGC between ~6.0 and 11kpc, spanning an age range of 60 to 500Myr. Among the about 7000 studied objects (cluster members plus nonmembers) we were able to find 48 new CP2's, 9 emission line stars and 27 objects which show a peculiar behaviour, but which is probably caused by binarity or variability.

The data of in total 465 frames was obtained at various observatories (ESO, Rozhen, CTIO, CASLEO and OSN), showing the flexibility of the photometric CP detection method. As an important application of the Δa system, isochrones were fitted to the color-magnitude-diagrams of the programme clusters, helping to improve the accuracy of the cluster parameters like age, distance and reddening.

Looking into the comprehensive database for open clusters WEBDA, it is apparent that there is a considerable lack of photometric data for about half of the more than 1700 known or suspected open clusters and therefore information about their age, distance and interstellar reddening is missing. To fill some of the white spots on the galactic map, we have initialized the broadband (UBV) survey of galactic open clusters using the 1.5m telescope of the Leopold Figl Observatory (FOA) at Mitterschöpfl to determine the cluster parameters age, distance and interstellar reddening.

The work by Netopil et al. (2006) comprises the photometric study of the poorly or non investigated northern clusters Basel 11b, Czernik 43 and King 14, whereas the latter is a possible member of a triple system. The middle aged clusters (logt = 7.6 to 8.4) are located at distances between 1.8 and 3kpc. Available 2MASS data was used as an independent verification of the determined parameters, showing a very good agreement.

The continuation of this work is in preparation, containing another set of marginally investigated clusters. Due to the new instrumentation at the FOA, implemented soon, this survey will be extended.