Stellar Clusters: Benchmarks for Stellar Physics and Galactic Evolution – EES2015
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FOREWORD

Research on stellar clusters is experiencing an exceptional revival due to new observational results obtained in particular with the VLT, the Hubble Space Telescope, and the Herschel satellite, as well as theoretical developments and cutting-edge numerical simulations. For instance, the results of the Herschel mission have lead to a new paradigm for stellar formation in clusters, while the discovery of multiple stellar populations in globular clusters by VLT and HST is recognized as one of the most spectacular results of the last decade. Furthermore, several infrared surveys (GLIMPSE, VVV) have allowed to discover many massive clusters that were unknown up to now, and that can contain the most massive stars ever discovered. Indeed, recent studies indicate that such clusters could harbor objects as massive as about 300 solar masses, which considerably modifies our understanding of the initial mass function as well as the formation process leading to massive stars. Such clusters are observed in different environments in the local Universe, but are presently spatially unresolved. They will be priority targets for future satellites and telescopes like the JWST and E-ELT.

Moreover, the study of the formation, dynamics, and evolution of clusters is crucial for understanding the origin and the properties of stellar populations in the Milky Way, and more generally in galaxies, which is one of the main goals of the Gaia mission launched by ESA in December 2013. Indeed, even if most stars are formed in groups or clusters hosting from a few tenths to several millions stars, only the more massive clusters remain gravitationally bound on lifetimes larger than the Hubble time, while the so-called open clusters and stellar associations quickly dissolve into their host galaxy.

Clusters are also cornerstones for understanding stellar physics and for constraining increasingly sophisticated models of stellar structure and evolution. In the modeling, it is becoming possible and necessary to account for various processes related to interactions between neighbor stars and with their environment (disc, planets, interstellar medium). These interactions, which strongly depend on the cluster density, affect the early evolution of stars by modifying their mass during accretion phases, their multiplicity rate, their disc, and, *in fine*, planetary formation and the initial mass function.

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Finally, it is very important to update our knowledge on stellar clusters, both close ones and clusters at high redshift, in order to have an overall picture and to be able to make the link between different populations. This is a key step to make to get prepared to the development of the theoretical, numerical, and observational tools, which are essential for maximizing the scientific return of the Gaia and JWST satellites as well as of ground-based instruments such as ALMA, NOEMA, and in the future SKA and E-ELT. This volume offers lectures given by world experts in the field during the Evry Schatzman School on Stellar Physics (EES 2015) held in Banyuls sur mer, France. The multiple facets of research on stellar clusters are reviewed, including observational, theoretical, and modeling aspects, and relating different fields of astrophysics like stellar physics, physics of galaxies, and interstellar medium physics. These reviews are also intended to facilitate the exploitation and interpretation of forthcoming observational data. The Herschel, Gaia, and JWST missions as well as the NOEMA and ALMA instruments, and later SKA and E-ELT, are improving (and will improve) our understanding of stellar clusters and their contribution to the different stellar populations in galaxies. This concerns very different and complementary astrophysical fields including the formation and initial mass function of stars and planets up to chemical and dynamical evolution of galaxies, but also the structuration of interstellar matter on different scales. For example, Herschel produced detailed maps of stellar formation regions in the Galaxy, while Gaia data (first data release in September 2016) is going to revolutionize our understanding of clusters and associations by probing their spatial and kinematical structures (in 6D). ALMA and then SKA, as well as JWST and later E-ELT, will offer first possibilities to spatially resolve the stellar population of young supermassive clusters in the local group, and to relate them to globular clusters. To take the full benefit of these high quality observations, numerical simulations of the dynamical evolution of clusters are essential. What are their present predictions, and how can we test them? What kind of new simulations will be necessary? The state-of-the-art on these crucial aspects is presented in the reviews. Therefore this book will be a valuable reference for researchers and students in the coming years.

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The organizers of EES 2015. From left to right: I. Joncour, Y. Lebreton, A. Robin, C. Charbonnel, E. Moraux.