

INTERNATIONAL ASTRONOMICAL UNION

INTER-DIVISION COMMISSION H4

Stellar Clusters throughout Cosmic Space and Time

Annual Report 2019

Organizing Committee

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Research of the commission H4 concerns star clusters, of any size, at any distance, and of any age, includes the observation and theory of stellar groupings as they form and evolve, cluster disruption, stellar interactions inside clusters, and star formation in dense environments.

The Commission H4 has an official newsletter: "The Stellar Clusters Young and Old Newsletter" (SCYON), edited by G. Carraro, M. Netopil and E. Paunzen, as a link to the scientific activity in the field.

In the following we outline some of the activities promoted and/or carried out by members of the commission in 2019.

Interconnections between the different topics (Associations and Young clusters; Old Clusters and Globular Clusters; Dynamics) have become increasingly important in recent years. For example, the study of old and young clusters has been connected through the attempt to understand the phenomenon of "Multiple Populations", initially limited to the chemical peculiarities of Galactic globular clusters stars, then extended to the study of clusters in the younger Magellanic Cloud satellite galaxies, and also young Galactic star clusters.

There has been intense on-going research in the following areas:

- the formation and dynamics of multiple stellar populations (for an excellent summary, see the review by R. Gratton et al. 2019 "What is a globular cluster? An observational perspective", *A&ARev.*, 27, 136);
- the study of the internal kinematics of globular clusters and the wealth of data from HST, Gaia, and ESO/VLT instruments;
- interplay between the dynamics and the formation of exotic stellar populations including possible sources of gravitational waves;
 - stellar streams, tidal tails, extra-tidal features around Galactic globular clusters;
 - the discovery of new star clusters in the Milky Way and in the Magellanic Clouds;
 - the formation of the Milky Way, important mergers (e.g. Gaia-Sequoia-Enceladus, etc), accreted and formed in-situ globular clusters: numerical simulations and observational results.

The main meeting sponsored in 2019 by Commission H4 was the IAU Symposium 351, held in Bologna (Italy) in May: "**Star Clusters: from the Milky Way to the Early Universe**", which also included the annual meeting of MODEST (see <http://iausymp351.oas.inaf.it>). A broad range of topics were discussed during the symposium and addressed all important aspects of the formation and dynamical evolution of star clusters. The Proceedings have already appeared in the IAU series Symposia (<https://ui.adsabs.harvard.edu/abs/2020IAUS..351.....B/abstract>) and constitutes a good reference point for recent work on the subject.

We list four other meetings that were devoted to research on Star Clusters and held in 2019:

- Formation of Stars and Massive clusters in Dwarf Galaxies over Cosmic Time (Workshop, Lorentz Center, Leiden, The Netherlands, Feb. 2019)

—Special Session 23 at EWASS 2019: The dynamics of stellar clusters: simulations and observations at low/high redshifts, Lyon, France, June

—From Gas to Stars: The Links between Massive Star and Star Cluster Formation, Yorkshire Museum, York (UK), Sept. 2019

—A Synoptic View of the Magellanic Clouds: VMC, Gaia and Beyond, ESO Workshop, ESO-HQ, 9-3 Sept. 2019

From the computational point of view, the development of the “Astrophysical Multipurpose Software Environment” (AMUSE) is on going (<https://amusecode.github.io>), and a book has been published “Astrophysical Recipes: the art of Amuse”, by Simon Portegies Zwart and Steve McMillan (<https://iopscience.iop.org/book/978-0-7503-1320-9>).

There are several web sites dedicated to research in the field of Commission H4, links for some of them can be found in the SCYON page:

<https://www.univie.ac.at/scyon/links.html>

We mention here two recent sites:

— GALFOR “Galactic Archaeology with Stellar Clusters”
<http://progetti.dfa.unipd.it/GALFOR/index.html> led by Antonino Milone

— “Fundamental parameters of Galactic Globular Clusters”
<https://people.smp.uq.edu.au/HolgerBaumgardt/globular/> by Holger Baumgardt