

The ExtreMe Matter Institute EMMI

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Since 2008 the Helmholtz Alliance ‘Cosmic Matter in the Laboratory’ is funded in the framework of the Alliance program of the Helmholtz Association. The aim of the Alliance program is to strategically enhance the profiles of the participating Helmholtz Centres and to transfer successful developments into one of the Helmholtz Association’s research programs. The research performed within the Helmholtz Alliances is collaborative and brings together universities, Helmholtz Centres and other non-university research institutions. In the case of the Alliance ‘Cosmic Matter in the Laboratory’ the funding contribution from the Helmholtz Association amounts to 18.745 Mio. Euro for six years.

A key step in the strategic positioning of the Helmholtz Alliance ‘Cosmic matter in the Laboratory’ was to establish a new, world-leading institute for research on matter at the extremes of density and temperature: the ExtreMe Matter Institute EMMI hosted by GSI. It was founded simultaneously with the start of the Alliance in April 2008.

The scientific aim of the ExtreMe Matter Institute is to perform forefront research in the area of matter under extreme conditions. This comprises in particular four key areas of the research field ‘Structure of Matter’ of the Helmholtz Association:

- quark-gluon plasma and the phase structure of strongly interacting matter
- neutron matter
- electromagnetic plasmas of high energy density
- cold quantum gases and extreme states in atomic physics.

The relevant science themes range from the quark-gluon plasma as it existed shortly after the Big Bang to ultracold quantum gases created in laboratory experiments, to the quantum dynamics of extreme fields, and from hot and highly compressed classical bulk plasmas to the astrophysically relevant dense medium of nucleons and neutrons that governs the properties of the evolution of supernovae and neutron stars. It hence comprises the study of the coldest, of the hottest, and of the densest known forms of matter in the Universe. The key idea is to conduct this research in an interdisciplinary framework, based upon common underlying concepts for the theoretical and phenomenological understanding of the physical phenomena in the four areas.

Under the lead management of the GSI Helmholtz Centre for Heavy Ion Research the Alliance links 13 German and international research centers and universities as partner institutions:

- GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

- Forschungszentrum Jülich, Germany
- Ruprecht-Karls-Universität Heidelberg, Germany
- Goethe Universität Frankfurt, Germany
- FIAS Frankfurt Institute for Advanced Studies, Germany
- Technische Universität Darmstadt, Germany
- Universität Münster, Germany
- Université VI, Paris, France
- Max-Planck-Institut für Kernphysik, Heidelberg, Germany
- Lawrence Berkeley National Laboratory, Berkeley, USA
- Joint Institute for Nuclear Astrophysics (JINA), USA
- RIKEN, Saitama, Japan
- University of Tokyo, Japan.

In addition, the Alliance benefits from the expertise of internationally renowned scientist who are closely linked to it as Associated Partners. Currently, the Alliance has 32 Associated Partners, among them two Nobel laureates. In total, more than 400 scientists contribute to the activities of EMMI.

The partner institutions have committed themselves to creating 18 senior positions, including full professorships and equivalent tenure-track and tenured positions, in the framework of the Alliance. By the end of 2012, 16 of these 18 positions are filled. Among these positions are four EMMI Fellow positions in experimental physics at GSI, one for each of the main research areas of EMMI. The EMMI fellows lead their own research groups and organize joint activities.

12 renowned experts have visited EMMI partner institutions for extended periods in 2012 as EMMI Visiting Professor, and have made progress in their collaborations with EMMI members.

EMMI is strongly committed to fostering the education and training of young researchers through a post-doctoral research program and training of graduate students. Structured PhD education for students within the Alliance is offered in close collaboration with the various Graduate Schools at the partner institutions, for example with the Helmholtz Graduate School for Hadron and Ion Research (HGS-HIRE), the Heidelberg Graduate School of Fundamental Physics (HGSFP) and the Helmholtz Research School Quark Matter Studies (H-QM). Many of the students in the Alliance have participated in various events (lecture weeks of HGS-HIRE, H-QM and HGSFP, graduate days of the HGSFP etc.) of these Graduate Schools in 2012.

An important activity of the ExtreMe Matter Institute EMMI is to organize and to host workshops and research

programs on topical and interdisciplinary subjects in the area of matter under extreme conditions. 7 EMMI Workshops and one four-week EMMI Program with strong international participation took place in 2012. In November 2012, the EMMI Physics Days were organized at GSI in which 174 EMMI members participated.

In addition, 29 'EMMI Seminars' were organized in 2012 in which external experts and guest scientists present their work on subjects related to EMMI. These seminars, mostly taking place in Darmstadt, form a nucleus for frequently attracting EMMI members from the nearby partner institutions.

Since 2012, EMMI provides the possibility to have talks at EMMI workshops recorded on video. The recorded talks are made available to all EMMI members and other interested scientists.

EMMI organized two masterclass events for high school students in 2012. In these masterclasses the students analyzed actual data from the ALICE experiment at the Large Hadron Collider at CERN. In total, 50 students participated in these masterclasses.

In 2012 the research within EMMI resulted in more than 300 publications in refereed journals. Many important results are described in various contributions to the GSI Scientific Report 2012.

