Major Opportunities for the Research Field Matter in Europe

Position paper by the centres in the Helmholtz Association active in the Research Field "Matter" to the Strategic Planning of Horizon Europe 2021-2024

1. Introduction

The scientific mission of the research field Matter is the exploration of the structure and properties of matter. This includes research on all-length scales, from the elementary building blocks of matter and the exploration of the quantum world to fundamental questions of the development of the universe. The understanding of complex interactions and processes on different length scales also serves as a basis for the development of new materials or drugs. While the core activities of the research field are in fundamental research, the applied research performed at the centres exploits its large research infrastructures (RI) which contribute to the research goals in the "*Global Challenges and European Industrial Competitiveness*", as well as to its Missions and European Partnerships.

2. Specific Considerations

The activities of the research field "Matter" tackle the grand challenges of the clusters and partnerships therefore match the scope of Horizon Europe. The centres of the Helmholtz Association active in the research field jointly formulate the following considerations:

2.1. Cluster Health

Under the Challenge "*Unlocking the full potential of new tools, technologies …*", the use of new techniques for particle and radiation therapy is gaining momentum and should be included in the Area of Intervention (AoI) since they also contribute to the Cancer Mission: Novel accelerator concepts and image-guided radiation therapy constitute a breakthrough towards treatment accuracy with reduced damage of healthy tissue and should be included into this AoI. The same is true for macromolecular crystallography and the analytical methods offered at large RI such as synchrotrons, free electron lasers and neutron sources which enable the imaging of new active compounds with unprecedented resolution and substantial impact e.g. on immunotherapy.

2.2. Cluster Digital, Industry and Space

In the AoIs "*Manufacturing technologies*", "*Advanced Materials*" and "*Emerging Enabling Technologies*" the use of large research infrastructures (e.g. light sources) is fundamental for *in operando* characterization and testing of advanced material production, also for 3D printing. In AoI "*Key Digital Technologies*", spintronics has been identified as one of the 100 radical innovation breakthroughs and must be explicitly mentioned in this AoI. Destruction-free *in situ* tools at large analytical RI plays a key role and must be mentioned. In AoI "*Advanced Computing and Big Data*", R&I for scalable and efficient long-term data management systems and storage technologies are needed in order to be able to apply novel data analyses and prediction methods on huge and complex datasets. In AoI "Space", the areas of health in space and space weather should be included.

2.3. Partnership on Key Digital Technologies

This future co-programmed partnership should see the involvement of Members States as evidenced by the successful example of ECSEL and should focus on low TRLs to help advance the spintronics area or quantum sensing using defects in industrial-compatible semiconductors, such as SiC.

2.4. Partnership Photonics Europe

This future co-programmed partnership should comprise activities on low TRLs to advance areas such the development of MEMs and NEMs. Access to large RI should be considered under this partnership. Heterostructures, correlated electron systems, topological states, quantum dots, as well as atom-scale quantum centres for on-demand photon generation should also be included.

2.5. European Partnership on Metrology

The future partnership under Art. 185 should include applications of synchrotron radiation sources enabling new high-resolution techniques (e.g. tribology) with high sensitivity and selectivity. The direct participation of large RI should be considered since they also develop key standardisation processes, e.g. in Quantum Metrology.

2.6. European Open Science Cloud

The future partnership should be implemented in the form of a co-funded model since the contribution of the Member States is vital for its successful adoption by the diverse scientific communities. R&I foreseen in the first four years shall focus on the enhancement of the scientific service portfolio (middleware for specific communities, including novel data analysis and prediction methods) and its connection with the federating core (scalable and efficient long-term data management systems and storage technologies) supported by the further coordinated development of the needed hardware resources of the European Data Infrastructure (EDI).

3. Role of Research Infrastructures in the Global Challenges, Missions and Partnerships.

Research Infrastructures (RI) have contributed to major discoveries such as exoplanets, the Higgs-boson and gravitational waves, as well as provided the first image of a black hole. In addition, the experiments performed at these RI have a substantial contribution to Pillar II, as well as to its Missions and European Partnerships. Such achievements require the development, construction, operation and **proper support of research infrastructures**. Therefore, the programme for RI in Horizon Europe should be supported in an adequate way with:

- Doubling the budget for the EU to have the world-class and cutting-edge RI needed to attract the best scientists and innovators and to seed the next scientific breakthroughs; a doubled budget is vital to ensure access to national RI across borders in Europe.
- Increased crosstalk between projects funded under the “Global Challenges”, those linked to Missions and under the EU Partnerships must take place with projects in the RI programme, without prejudice to the budget increase for the RI programme under HE.
- Fair and thorough transnational access programme for researchers to RI, efficiently organised and directly supported under HE, to avoid discrimination of researchers from EU countries without own comparable RI.
- A federated approach to the operation and upgrade of similar RI across Member States that goes beyond ESFRI (e.g. emergence of advanced communities as MS-driven initiatives for particular RI, when suitable).

Activities in the research field “Matter” for the period 2021-2027 are pursued at 8 Helmholtz Centres: *The Deutsches Elektronen-Synchrotron DESY, the Forschungszentrum Jülich, the Karlsruhe Institute of Technology (KIT), the Helmholtz-Zentrum Geesthacht for Materials and Coastal Research, the GSI Helmholtz Centre for Heavy Ion Research, the Helmholtz-Zentrum Berlin for Materials and Energy, the Helmholtz-Zentrum Dresden-Rossendorf and the Max Planck Institute for Plasma Physics (IPP, associated centre).*

Brief portrait of the Helmholtz Association

Helmholtz contributes to solving major challenges facing society, science, and the economy through top-level scientific achievements in six Research Fields: Energy, Earth and Environment, Health, Key Technologies, Matter, and Aeronautics, Space, and Transport. With more than 40,000 employees at 19 Research Centers and an annual budget of around 4.7 billion euros, Helmholtz is the largest scientific organization in Germany. Its work is rooted in the tradition of the great natural scientist Hermann von Helmholtz (1821–1894).

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