Report of
Mirko Mauri

Group Leaders of
Birational geometry and integrable systems

in the Hausdorff Junior Trimester Program
Algebraic geometry: derived categories, Hodge theory, and Chow groups

Group members

- Alessio Bottini (Università di Roma Tor Vergata)

- Andres Fernandez Herrero (Columbia University)

- Mirko Mauri (Institute of Science and Technology Austria)

- Roberto Svaldi (Università degli Studi di Milano)

- Ruijie Yang (Humboldt-Universität zu Berlin)

Group leaders

- Mirko Mauri (Institute of Science and Technology Austria)

- Roberto Svaldi (Università degli Studi di Milano)

Guest members of the group

- Mark Andrea de Cataldo (Stony Brook University)

- Philip Engel (University of Bonn)

- Stefano Filipazzi (École Polytechnique Fédérale de Lausanne)

- Roberto Fringuelli (Sapienza Università di Roma)

- Francois Greer (Michigan State University)

- Enrica Mazzon (Universität Regensburg)

Events organized by the group members

- Felix Klein Lectures, titled *Families of higher dimensional varieties*, delivered by Professor János Kollár (Princeton University), see video. The Felix Klein Lectures are a series of prestigious lectures delivered each year by an eminent researcher. This year, the afternoon lectures were preceded by inspiring morning Q&A sessions during which each participant presented their current research problem, followed by discussions involving Professor János Kollár and the audience.

- Birational workshop, see program. This one-week workshop brought together leading experts in the field and focused on the interplay between several central topics: birational geometry, foliations, hyperkähler geometry, Hodge theory, stacks, and methods in positive characteristic.

- Learning seminar *Degeneration of hyperkähler varieties*, see program. Each week, participants gave introductory and expository talks on the geometry of degenerations of varieties, with a special focus on hyperkähler varieties.

- Mathenacht public lecture, titled *A journey through high dimensions: from Dante to modern algebraic geometry*, delivered by Mirko Mauri, see website. Mathenacht is an outreach event jointly organized by the Mathematics Excellence Cluster MATH+ (Berlin), the Hausdorff Center for Mathematics (University of Bonn), and Mathematics Münster (University of Münster). I presented aspects of cutting-edge research — such as the P = W conjecture — by linking modern algebraic geometry with classical literature, architecture, art, and music, offering a fresh perspective designed to resonate with a general audience.

Events coorganized with the other groups of the JTP

- Weakly research seminar series

    - SAG (Seminar of Algebraic Geometry)
    - MAGHI (More Algebraic Geometry at the Hausdorff Institute)

- Mini-courses, i.e., intensive courses of three lectures concentrated in a single week delivered by a participant of the program or a guest member

- *Compact Moduli spaces of K3 surfaces* by Philip Engel (University of Bonn)
- *Shifted Symplectic Structures* by Hyeonjun Park (Korea Institute for Advanced Study);
- *Quasi-BPS categories* by Tudor Padurariu (MPIM Bonn) and Yukinobu Toda (Kavli IPMU, University of Tokyo);
- *Sheaves on hyperkähler manifolds and deformation theory* by Alessio Bottini (Università di Roma Tor Vergata).

Research Impact

The Junior Trimester Program had a significant impact on the development of the research projects of the members of our group.

Together with Roberto Svaldi, Stefano Filipazzi, François Greer, and Philip Engel, we initiated discussions on a promising new project aimed at bounding the deformation types of Calabi–Yau varieties fibered in K3 or abelian varieties. This is a key open problems concerning the classification of algebraic varieties. The direction appears fruitful, and we anticipate submitting a preprint to the arXiv in the coming months.

A complementary approach to studying algebraic varieties involves degenerating them, and encoding their geometric properties in the combinatorial structure of the limit. In collaboration with Philip Engel, I also began a project on degenerations of hyperkähler varieties. We proved that all irreducible components of the limit variety are log symplectic, and in the case of Type II degenerations, the minimal strata are always isogenous to a power of an elliptic curve. (Previously, it was only known that the minimal stratum had trivial canonical bundle.) Discussions with Brent Pym during his visit to Bonn for the birational geometry workshop were particularly valuable. We continued developing this project at a follow-up meeting during the AIM workshop, which I co-organized with Yoshinori Gongyo, Joaquín Moraga, and Roberto Svaldi.

I also had the opportunity to collaborate in person for the first time with Mark de Cataldo, Roberto Fringuelli, and Andres Herrero — long-time collaborators — on our ongoing project concerning the decomposition theorem for the Hitchin integrable system. This in-person interaction provided substantial momentum. The first paper, in what is expected to be a series of three, has already appeared on the arXiv. During our stay in Bonn, we also developed the idea of analyzing the dependence of the cohomology of moduli

spaces of G-Higgs bundles on their degree. This line of inquiry may lead to a resolution of the topological mirror symmetry conjecture proposed by Hausel and Thaddeus.

Finally, in collaboration with Valeria Bertini, Annalisa Grossi, and Enrica Mazzon, we completed a paper during our stay at HIM, which has since been published in Épijournal de Géométrie Algébrique.

Preprints connected with the JTP

Mark de Cataldo, Andres Herrero, Mirko Mauri, and Roberto Fringuelli, *Hitchin fibrations are Ngô fibrations* arXiv:2502.04966, pp.98

Valeria Bertini, Annalisa Grossi, Mirko Mauri, and Enrica Mazzon, *Terminalizations of quotients of hyperkähler manifolds by symplectic automorphisms* to appear at EPIGA, arXiv:2209.00621, pp.47

Acknowledgment