

COMMISSION F4

ASTEROIDS, COMETS AND TNOs

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TRIENNIAL REPORT 2021-2024

1. Introduction

The Commission F4 was approved and formed in August 2021. It brings together the international scientific community involved in the study of small bodies. Although this commission is considered new, it is intended to resume the activities of the previous Commission 15 (1935-2015), which was dissolved under the reorganization of the IAU structure. The main responsibility of the Commission is to promote progress on the physical studies of asteroids, comets, transneptunian objects (TNOs) and to support synergy and collaboration of observational, experimental, and theoretical research across groups studying small bodies. As of 2024, the Commission F4 includes 254 members, working on various aspects of small body studies. The Commission actively collaborates with Inter-Division A-F working group Near Earth Objects and IAU Minor Planet Center User's Group (MPC MUG).

2. Main activities

The research activity on asteroids, comets and TNOs spans a variety of approaches and has been extremely productive, as demonstrated by over 1200 peer-reviewed papers published each year over the past triennium. The obtained new results were broadly discussed among OC and Commission members in order to highlight and promote the most important findings. The highlights have been posted on the IAU Commission F4 webpage.

The Commission members have significantly contributed to ongoing space missions to small bodies. The past three years were marked by two successful sample return missions to primitive asteroids: JAXA's Hayabusa2 and NASA's OSIRIS-REx. The analysis of samples (5.4 g) of the asteroid Ryugu returned by Hayabusa2 and samples (121.6 g) of the asteroid Bennu returned by OSIRIS-REx opened a new era in the study of the early Solar system's pristine material and its evolution. The NASA Double Asteroid Redirection Test (DART) was aimed at testing an asteroid deflection technique, and the mission successfully executed its intentional crash into Dimorphos, the satellite of asteroid Didymos. The immediate aftermath of the crash was imaged by the LICIACube cubesat of the Italian Space Agency. Telescopes around the globe and in space monitored

these asteroids before and after impact, leading to a measured decrease by 33 minutes of the initial orbital period of 11 hours and 55 minutes of Dimorphos. Successful launches of NASA’s Lucy mission (2021) and Psyche mission (2023) open a new window on our Solar system history aimed in exploring of Jupiter Trojans and a metal-rich asteroid. The Lucy mission’s first flyby in 2023 of Dinkinesh showed us up-close images of the smallest Main Belt asteroid to date, and revealed a binary moon around this object. Both JAXA’s Hayabusa2 and NASA’s OSIRIS-REx missions extended their scope, targeting the exploration of three other near-Earth asteroids, and NASA’s New Horizons mission is still exploring the Kuiper Belt. The results of the study of the Pluto system and insights into the nature of TNOs were presented in the book “*The Pluto System after New Horizons*” (2021, University of Arizona Press).

Commission members are also working on missions in development that will advance small body science. The ESA Comet Interceptor mission is going to be the first mission to visit a long-period comet. The United Arab Emirates (UAE) Space Agency, which successfully performed the HOPE mission to Mars that included a flyby and new images of Deimos, is now developing the Emirates Mission to the Asteroid belt (EMA). The mission will launch in 2028 to perform 7 asteroid fly-bys, ending with a rendezvous and landing on the asteroid Justitia. The NEO Surveyor mission will launch in 2027, and will conduct a dedicated survey of hazardous asteroids, measuring the orbits and sizes for an order of magnitude more objects than are currently known in the inner Solar system.

The last triennium has revealed increasing capabilities of space-based observations of small bodies. Small body science results from the James Webb Space Telescope (JWST) has started to be published, in particular a water emission from a main-belt comet was detected for the first time. The observation of the DART impact on Dimorphos was performed using JWST and the Hubble Space Telescope simultaneously, this is the first time those two space telescopes pointed to a same object. The observations by the Transiting Exoplanet Survey Satellite (TESS) and the extended K2 mission of the Kepler Space Telescope continued to be explored as a valuable resource for characterizations of asteroids, comets and TNOs. The ESA Gaia mission data has significantly increased the accuracy of asteroid orbits, mass determinations, and predictions of stellar occultations.

Ground-based observations of small bodies benefit from combining different techniques and dedicated surveys. The reconstruction of 3D shapes of the largest asteroids became possible using SPHERE at the ESO VLT. A dense ring was discovered outside the Roche limit of the trans-Neptunian object Quaoar, along with a second ring beyond Quaoar’s classical Roche limit. New constraints on shape and surrounding material of Centaur Chiron were found by stellar occultations.

Faced with exponential data growth, advanced methods to combine diverse data types and modeling to increase the scientific output using multiple datasets are rapidly evolving. Laboratory experiments and measurements have reached both a qualitatively and a quantitatively new level with asteroid samples available. New models have been developed to determine terrestrial planet and asteroid belt formation. New constraints favoring the existence of an Earth-like planet and several TNOs on peculiar orbits in the outer solar system were discovered.

3. New data sources available for community

The Data Release 3 by the ESA Gaia mission (2022) and Gaia’s Focused Product Release (2023) unveiled a groundbreaking dataset, including 5 years of asteroid astrometry

for over 150,000 asteroids and visible spectra for 60518 asteroids. These data are expected to be a primary source for many advances in asteroids science in the next years.

The release of Open Database Network SsODNet, a new information service on Solar System Small Bodies, provided a wealth of data compiled from 5.5 million numbers, names, designations, and 192 million parameters sourced from approximately 3300 articles.

A new version of the Catalogue of Asteroid Polarization Curves has been released, including the first results of the Calern Asteroid Polarimetric Survey, one of the major currently active projects aimed at increasing the available database of asteroid polarimetric data.

4. Meetings

These and other scientific results related to small bodies study were widely presented at various meetings and workshops by members of the Commission. The most important meeting for the Commission F4 members was Asteroids, Comets, Meteors (ACM) Conference on June 18 – 23, 2023 in Flagstaff, USA. The ACM conference takes place every three years since 1983 and is the main forum for researchers working on small body investigations.

Sessions on small bodies were organized at the Annual DPS Meeting of Planetary Sessions (Oct 8-13, 2021, virtual; Oct 2–7, 2022, London, Ontario, Canada), at the Europlanet Science Congress EPSC (Sep 13-24, 2021, virtual; Sep 18-23, 2022; Granada, Spain) and at the joint DPS-EPSC meeting (Oct 1–6, 2023, San Antonio, Texas, USA).

Meetings devoted to small bodies were also organized at different countries:

- Modern trends in studies of physics and dynamics of the Solar system bodies, Oct 4-5, 2021, Shamakhy Astrophysical Observatory, Azerbaijan;
- IAA Severo Ochoa Meeting: Addressing key astrophysical questions from Granada, Oct 18- Oct 21, 2022, Granada, Spain;
- The Exploration of Asteroids Symposium, Nov 7-11, 2022, ESA/ESTEC, Noordwijk, Netherlands;
- Active small bodies in the Solar System over a wide range of heliocentric distances, Sep 5-8 2023, Stará Lesná, Slovakia;
- International Churyumov Readings COMETS, ASTEROIDS, METEORS, METEORITES, ASTROBLEMES, CRATERS (CAMMAC-2023), Oct 31 – Nov 3, 2023, Kyiv, Ukraine;
- XVII Latin American Regional IAU Meeting, Nov 27-Dec 1, 2023 - Friday, Montevideo, Uruguay;
- Meetings on Planetary Sciences, Feb 14-18, 2022, Virtual Meeting; Feb 26 – Mar 1, 2024, Rio de Janeiro, Brasil.

The Organizing Committee contributed to the several proposals of IAU Symposia and FM and organization of Focus Meetings for IAU GA in 2022 (FM8: Astronomy via Telescopic and Microscopic Approaches) and in 2024 (FM3: Follow-up Observations of Small Bodies in the Solar System in the Era of Large Discovery Surveys).

5. Future plans

Future work for Commission F4 includes supporting the multiple international exploration missions that will focus on small bodies that are planned to launch in the coming years. Commission members will work to increase awareness of these missions in their

home communities, and the Organizing Committee will communicate with members key talking points that will be of public interest.

The Organizing Committee will also support the team that will plan the 2026 Asteroids, Comets, and Meteors conference in Poland.

Finally, the Organizing Committee will recruit from the members of the Commission proposals for Focus Meetings and/or Symposia for the 2027 IAU General Assembly. The Letter of Intent deadline is Dec 1, 2025, but initial work will need to begin 6-12 months before this date. The Organizing Committee will use the Division Days at the 2024 meeting to strategize with Commission members on possible topics.

Irina Belskaya
President of the Commission