Recent achievements in the exploration of the solar system

Plenary Session

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For the past 10 years, space missions have explored astronomical bodies in the solar system, including asteroids, the Moon, Mercury, Venus, and Mars. Hayabusa2 is a Japanese Space Agency (JAXA) space mission, which rendezvoused the primitive carbonaceous near-Earth asteroid Ryugu and returned samples to Earth in December 2020. Preliminary results indicate the presence of volatile-rich species which likely originated from the outer solar system [1]. This information will be complemented by the future analyses of the Origins Spectral Interpretation Resource Identification Security Regolith Explorer (OSIRIS-Rex) asteroid sample-return mission. This mission from NASA to asteroid Bennu successfully collected a sample from the asteroid in October 2020 and is expected to return to Earth in 2023. Preliminary results indicates the presence of carbonates and organics matter on Bennu [2]. Both Hayabusa2 and OSIRIS-Rex will inform on the conditions of the early solar system, including the sources of organic compounds that may have played a role in the origin of life in our planet. Mercury and Venus have both been object of study by orbiters in the last decade. BepiColombo, a joint mission of the European Space Agency (ESA) and JAXA, was launched in 2018, and will arrive at Mercury in 2025 to study its magnetic field, magnetosphere, interior and surface structure [3]. The JAXA space probe Akatsuki was successfully placed into the Venusian orbit in December 2015 and is since then studying the atmosphere of Venus [4]. The Moon has been frequently visited by spacecrafts, orbiters, and rovers since 2011. The American Gravity Recovery and Interior Laboratory (GRAIL) was composed of two orbiters that determined the lunar interior structure [5], later impacting its surface. The China National Space Administration (CNSA) has had a serious of missions to explore the Moon, known as the Chinese Lunar Exploration Program, or Chang'e project [6]: the orbiter Chang'e 1 produced a map of the entire lunar surface, and it was followed by the Chang'e 2 orbiter. The second stage of this project included the Chang'e 3 lander and rover, and Chang'e 4 which landed on the far side of the Moon. The third stage includes the Chang'e 5 mission, which landed on the Moon in December 2020, and it was China's first lunar sample-return mission. Many space missions have been orbiting Mars, including the Mars Atmosphere and Volatile Evolution (MAVEN) [7], ExoMars Trace Gas Orbiter (TGO) [8], Mars Orbiter Mission (MOM) by the Indian Space Research Organisation (ISRO), and the Hope orbiter by the United Arab Emirates Space Agency. In 2012, the Mars Science Laboratory (MSL) successfully landed the Curiosity rover, which has been studying the habitability, climate, and geology of Mars [9]. The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) is a robotic lander that has been studying the interior of Mars, i.e., to measure its seismic activity, and its internal heat transfer [10]. In 2021 Mars was visited by the rover Perseverance and the small helicopter Ingenuity (part of the Mars 2020 mission), and the Zhurong rover (from the Tianwen-1 mission), which is studying the topography and geology of Mars while also sampling the atmosphere [11]. To note that Perseverance is investigating the habitability conditions of Mars and its surface geological processes, and it will collect samples into containers, that will later be retrieved by a future Mars sample-return mission [12]. In this talk we will discuss the major achievements in the exploration of our solar system in the

last decade. [1] Pilorget, C. et al. (2022) Nature Astronomy 6, 221. [2] Ferrone, S. M. et al. (2022) Icarus 368, article id. 114579. [3] Benkhoff, J. et al. (2021) Space Science Reviews 217, article id.90. [4] Fukuya, K. et al. (2021) Nature 595, 511. [5] Andrews-Hanna, J. C. et al. (2014) Nature 514, 68. [6] Lin, X. et al. (2018) Chin. J. Space Sci. 38, 591. [7] Bougher, S. et al. (2015) Science 350, id.0459. [8] Korablev, Oleg et al. (2019) Nature 568, 517. [9] Leshin, L. A. et al. (2013) Science 341, id. 1238937. [10] Khan, A. et al. (2021) Science 373, 434. [11] Liu, J. et al. (2022) Nature Astronomy 6, 65. [12] Mangold, N. et al. (2021) Science 374, 711.