TULIP: Taiwan University Lunar Investigation Project. W.-H. Ip[1], I.-L. Lai[1], Z.-Y. Lin[1], Y.-P. Chen[2], C.-Y. Hsu[1], and T.-M. Yang[3], [1]Graduate Institute of Astronomy, National Central University, Taiwan, [2]Department of Physics, National Central University, Taiwan, [3]Department of Space Science and Engineering, National Central University, Taiwan (wingip@astro.ncu.edu.tw).

Introduction: The Taiwan University Lunar Investigation Project (TULIP) is supported by the National Council of Science and Technology (NSTC) to promote lunar research in Taiwan. It currently consists of several scientific components: (1) model simulations of the lunar exosphere and volatile transport generated by solar radiation, solar wind interaction and micrometeoroid bombardment; (2) ground-based monitoring of meteoroid impact flashes on the lunar surface; (3) long-term monitoring of the lunar sodium tail. We are making good progress on these topics and the results will be reported with a view to solicit cooperation from the international community.

Lunar exosphere simulations: In the gravitationally bound exospheres of massive airless planetary bodies like the Moon and Mercury, atoms and molecules undergo far more collisions with the planet surface than with each other [1] [2]. All the species in the exosphere also behave differently. Hence, the interactions between gas and the lunar surface play a pivotal role in determining the distribution, composition, and temporal variability of the lunar atmosphere. In our research, we identify several primary sources contributing to the gaseous composition of the lunar exosphere: interactions with the solar wind, bombardment by micrometeoroids, and endogenic activities, such as radioactive decay. To comprehensively study the distribution and temporal variation within the lunar exosphere, this work aims to develop a time-dependent model.

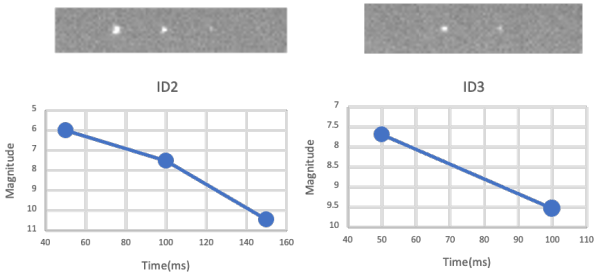

Figure 1 Two examples of the lunar impact flash images and the brightness curves on Nov 21, 2023.

Lunar flash monitoring: Impacts of meteoroids on the Moon could be observed as optical flashes [3]**.** The focus of this work is on the frequency of meteoroid impacts on Moon to estimating the physical parameters of these meteoroids as well as the impact physics parameters. Therefore, we constructed the observational system (Robotic Lulin lunar Impact Flash tElescope, RoL IFE) at Lulin observatory in Taiwan and set up the Taiwan Astronomical Network of Ground-based Observations (TANGO) for lunar impact flash observations. Figure 1 shows two examples of the lunar impact flash and the light curves detected on Nov 21, 2023.

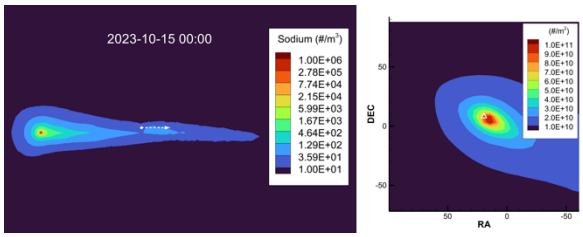

Figure 2 A simulation result of lunar sodium tail. Left: A slice of sodium tail and Earth's gravitational effect. Right: The sodium tail bright spot on the sky.

Sodium tail observations: The lunar sodium tail is a comet-like extension of the sodium exosphere, formed by the high speed and escaping sodium atoms under the influence of solar radiation pressure. Because of the strong absorption line in D1 and D2 of sodium, the emission could be detected by the ground-based observations [4]. The sodium" bright spot" which is the sodium tail focused by the Earth's gravitational force in the anti-solar direction [5] [6]. In this work, we have set up an all-sky camera system on the Lulin observatory to monitor the lunar sodium tail bright spot. Figure 2 shows the simulation result of the bright spot and sodium tail.

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Reference: [1] Milillo et al., Space Science Reviews (2023) [2] Grava et al., Space Science Reviews (2021) [3] Oritz et al., Nature (2000) [4] Potter & Morgan, Science (1988) [5] Matta et al., Icarus (2009) [6] Line et al., Icarus (2012)