

## Rendezvous with Toutatis from the Moon: The Chang'e-2 mission

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Chang'e-2 probe was the second lunar probe of China, with the main objectives to demonstrate some key features of the new lunar soft landing technology, and its applications to future exploration missions. After completing the planned mission successfully, Chang'e-2 flew away from the Moon and entered into the interplanetary space. Later, at a distance of 7 million km from the Earth, Chang'e-2 encountered asteroid (4179) Toutatis with a very close fly-by distance and obtained colorful images with a 3-m resolution.

Given some surplus velocity increment as well as the promotion of autonomous flight ability and improvement of control, propulsion, and thermal systems in the initial design, Chang'e-2 had the capabilities necessary for escaping from the Moon. By taking advantage of the unique features of the Lagrangian point, the first close fly-by of asteroid Toutatis was realized despite the tight constraints of propellant allocation, spacecraft-Earth communication, and coordination of execution sequences. Chang'e-2 realized the Toutatis flyby with a km-level distance at closest approach. In the absence of direct measurement method, based on the principle of relative navigation and through the use of the sequence of target images, we calculated the rendezvous parameters such as relative distance and image resolution. With the help of these parameters, some fine and new scientific discoveries about the asteroid were obtained by techniques of optical measurements and image processing.

Starting with an innovative design, followed by high-fidelity testing and demonstration, elaborative implementation, and optimal usage of residual propellant, Chang'e-2 has for the first time successfully explored the Moon, L2 point and an asteroid, while achieving the purpose of 'faster, better, cheaper'. What Chang'e-2 has accomplished was far beyond our expectations.

\*J. Huang is the chief designer (PI) of Chang'e-2 probe, planned Chang'e-2's multi-objective and multitasking exploration mission.