GERMAN LUNAR EXPLORATION ORBITER (LEO): PROVIDING A GLOBALLY COVERED, HIGHLY RESOLVED, INTEGRATED, GEOLOGICAL, GEOCHEMICAL, AND GEOPHYSICAL DATA BASE OF THE MOON. R. Jaumann[1,3], T. Spohn[1,2], H. Hiesinger[2], E. K. Jessberger[2], G. Neukum[3], J. Oberst[1], J. Helbert[1], U. Christensen[4], H.U. Keller[4], U. Mall[4], P. Hartogh[4], K.-H. Glassmeier[5], H.-U. Auster[5], A. Moreira[6], M. Werner[6], M. Pätzold[7], H. Palme[8], R. Wimmer-Schweingruber[9], M. Mandea[10,5], F. Flechtner[10], V. Lesur[10], B. Häusler[11], R. Srama[12], S. Kempf[12], A. Hördt[5], K. Eichentopf[1], E. Hauber[1], H. Hoffmann[1], U. Köhler[1], E. Kührt[1], H. Michaelis[1], M. Pauer[1], F. Sohl[1], T. Denk[3], S. van Gasselt[3].

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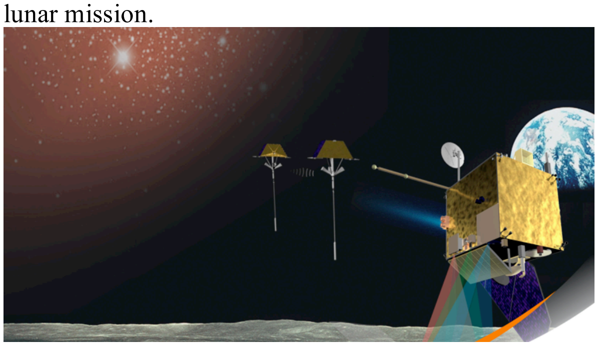
Introduction: The German initiative for the Lunar Exploration Orbiter (LEO) originated from the national conference “Exploration of our Solar System”, held in Dresden in November 2006. Major result of this conference was that the Moon is of high interest for the scientific community for various reasons: it is affordable to perform an orbiting mission to the Moon and it insures technological and scientific progress necessary to assist further exploration activities of our Solar System. Based on scientific proposals elaborated by 50 German scientists in January 2007, payload of 12 instruments was defined and selected. Further, a mission definition study performed by the German industries demonstrated the feasibility of a national lunar mission.



LEO is planned to be launched in 2012 and shall orbit the Moon for about four years at low altitude (<50 km) in order to map the Moon geomorphologically, geochemically and geophysically with resolutions down to less than1m globally.

Scientific approach: The Moon is an integral part of the Earth-Moon system, it is a witness to more than 4.5 b.y. of solar system history, and it is the only planetary body except Earth for which we have samples from known locations. The vast amount of knowledge gained from the Apollo and other lunar missions of the late 1960's and early 1970's demonstrates how valuable the Moon is for the understanding of our planetary system. Even today, the Moon remains a scientifically and technologically extremely interesting target as many open questions about the Earth-Moon system still exist, even though new data since Apollo have addressed some of them. Therefore, returning to the Moon is the critical stepping-stone to further exploring our immediate planetary neighborhood.

Understanding the origin and evolution of the terrestrial planets including Earth requires information about early differentiation, volcanism and related tectonism. However, the physics and chemistry of these processes and its chronological sequences are not completely known. The Moon’s composition is, due to the lack of water and its restricted geological active phase, relatively simple and thus provides insight into planetary processes that are much more obscured on other bodies. In particular, Earth and Venus exhibit extremely young surfaces, containing almost no record of the early evolution of a planet. Thus, evidence on how planets differentiate, of how early magma oceans operate as well as on secondary differentiation and initial volcanism is restricted to the Moon. Earth and Moon form a common tidally evolved planetary system that is unique among the terrestrial planets. Is there a direct correlation of the specific evolution of Earth including life and the existence of the Moon? The Moon is thought to be the product of an early planetary collision of a Mars-sized body with Earth. However this model needs to be confirmed by measurable “truth”. Datingof planetary surface and thus of planetary processes like emplacement of lava, collision events, and breaking of the crust depends on the distribution and frequency of impact craters. This statistical method is based on the long record of impacts known from the lunar surface and correlations with the absolute age of lunar samples. However, particularly small impact craters that are needed to improve the accuracy of this dating method are not mapped out globally. As the Moon has no atmosphere its surface will not only collect impacts of smallest scale but is hit by sizes down to the particles of the solar wind. The surface debris called regolith has thus collected information about activities in our space environment over time until the beginning.

A necessary further step in investigating the Moon is getting a global and integrated view of its geology, geochemistry and geophysics at highest resolution down to meter scale. In particular, we need to significantly improve our understanding of the lunar surface structure and composition, surface ages, mineralogy, physical properties, interior, thermal history, gravity field, regolith structure, and magnetic field. A low altitude orbiting spacecraft, equipped with a wealth of high-resolution remote sensing instrumentation, can achieve such a goal. Highest resolution geological, geochemical and geophysical mapping will provide the unambiguously needed information to plan landings and future utilization of the Moon.

Numerous space-faring nations have realized and identified the unique opportunities related to lunar exploration and have planned missions to the Moon within the next few years. Among these missions, LEO will be unique, because it will globally explore the Moon in unprecedented spatial and spectral resolution: < 1 m in stereo, < 10 m spectrally (0.2 – 14 µm), 2 m subsurface resolution, and 0.2 mGal for lunar gravity at 50 km resolution. Therefore, LEO will significantly improve our understanding of the lunar surface composition, surface ages, mineralogy, physical properties, interior, thermal history, gravity field, regolith structure, and magnetic field. The Lunar Exploration Orbiter will carry an entire suite of innovative and complementary technologies, including a high-resolution stereo camera system, several spectrometers that cover previously unexplored parts of the electromagnetic spectrum over a broad range of wavelengths, microwave and radar experiments, a very sensitive magnetometer and, and two subsatellites. The Lunar Explorations Orbiter concept is technologically challenging and will gather unique, integrated, interdisciplinary data sets that are of high scientific interest and will provide an unprecedented new context for other international lunar missions. With its high visibility, LEO will foster the growing acceptance of space exploration in Germany and will capture the imagination of the general public.

The most visible mission goal will be the global mapping of the lunar surface with high spatial as well as spectral resolution. Therefore, in addition to a stereoscopic global mapping in the meter range, a screening of the electromagnetic spectrum within a very broad range will be performed. In particular, spectral mapping in the ultraviolet and mid-infrared will provide insight into mineralogical and thermal properties so far unexplored in these wavelength ranges. Fine scale analysis of the lunar regolith by radar sounding will provide structural information about regolith layering. The determination of the dust distribution in the lunar orbit will provide information about processes between the lunar surface and exosphere supported by direct observations of lunar flashes. The geophysical properties of the Moon will be investigated by recording the magnetic and gravitational field with so far unrivalled accuracy due to the low orbit, stable sub-satellites and specific tracking. Measuring of the radiation environment will finally complete the exosphere investigations. Combined observations based on simultaneous instrument adjustment and correlated data processing will provide an integrated geological, geochemical and geophysical database that yield the comprehensive scientific source for any further lunar exploration.

Summary: LEO is featuring a set of unique scientific capabilities w.r.t. other planned missions including: (1) 100% global coverage of he lunar surface with all remote sensing instruments with stereo resolutions of <1 m and spatial resolution of the spectral bands of <10 m. (2) Besides the VIS-NIR spectral range so far uncovered wavelengths in the ultraviolet (0.2 – 0.4 µm) and mid-infrared (7 - 14 µm) will be globally mapped. (3) Global coverage and subsurface detection of the regolith with vertical resolutions of about 3 m down to a few ten meters (high resolution Synthetic Aperture Radar with 25cm wavelength) and on mm-scale within the first 2 m (microwave-instrument) will investigate the regolith's structure. (4) Detailed measurements of the lunar gravity field and magnetic field from a low orbit (<50 km) using two subsatellites and simultaneous Earth tracking, supported by a radiation monitor and two independent magnetometers, will provide high precision and, in addition, will enable to geophysically investigate the lunar far side. (5) The long mission duration of 4 years yields multiple high resolution stereo coverage and thus monitoring of new impacts; this is supported by a flash detection camera searching directly for impact events and dust detection in the exosphere.

LEO is currently in a phase A. The mission scenario foresees a launch in early 2012, a five-day lunar transfer, a two-month commissioning phase and a four year mapping phase.