PRESS PACK – MAX-PLANCK-INSTITUT FÜR SONNENSYSTEMFORSCHUNG

THE CHANDRAYAAN-1 MISSION AND THE MAX PLANCK SOCIETY CONTRIBUTION: THE SIR-2 - *15-10-2008*

On October 22, the Chandrayaan-1, the first Indian mission to the Moon, will take off from Shriharikota carrying a multinational scientific payload consisting of five indigenous remote sensing instruments and six complementary guest payloads from as many countries. A truly international and multidiscipline scientific effort aimed at unleashing and improving our understanding of the Moon.

The overall scientific objective of the mission is a comprehensive and simultaneous geochemical, mineralogical, and photogeological study of the whole lunar surface.

Chandrayaan-1 represents an exceptional and unique commitment to space research thanks to its wide scientific scope, extended duration (two years), an optimal observing point (a circular 100 km lunar orbit), and multidisciplinary approach.

During the two-year mission, the lunar surface will be mapped in greater detail than before, aiming at producing three-dimensional topographic atlas of the surface with a five-meter resolution, enriched by accurate laser-derived altimetry and gravity data.

Other sophisticated instruments will study the lunar environment, including measuring the Moon's tenuous atmosphere, and the effects of 'space weathering' on surface materials, caused by the continuous 'rain' of solar and cosmic particles.

Vital data will be acquired in aid of future manned mission to the Moon, including spacecraft landing dynamics, the radiation environment and effects, and, crucially, confirm the presence of water ice in sheltered areas of the lunar poles, following tantalising clues from previous lunar missions.

Finally, and representing the main focus of the mission, six out of the eleven instruments on board will target the composition and distribution of the exposed (rock) materials on the lunar surface. With unprecedented accuracy and resolution various instruments will observe the Moon using reflected x-rays to understand the mechanisms of potential water transport to the lunar poles, and, significantly, the spatial distribution of fundamental planetary elements such as aluminium, silica, magnesium and iron. Three other instruments will apply the principles of spectroscopy in an individual but complementary effort to produce high resolution mineral maps of the lunar surface.

One of the spectrometers, the SIR-2 (Spectrometer InfraRed), will represent the German scientific contribution to the mission, a project funded by the Max Planck Society (MPS) and the European Space Agency (ESA).

The SIR-2, designed and built in Katlenburg-Lindau by MPS, is a highly sophisticated instrument designed to investigate the mineral composition of lunar surface materials. It accomplishes this by splitting the reflected lunar light into its basic 'colour' components, like a prism resolving sunlight into a rainbow.
By reading the intensities (read strength) of key 'colours' and comparing these to known mineral 'fingerprints' obtained from lab studies, it is possible to estimate the type of minerals (exposed) on the lunar surface, all from an (orbital) distance of 100 km!

This document comprises four further sections:

Background - **A 'Lunar Science' essay** – A semi-serious introduction to the scientific reasons and needs behind the SIR-2 mission (…and others').

Background **–** Introduction to **Origin and evolution of the Moon** – A 'bullet point', telegraphic summary of the origin and (geological) evolution of the Moon.

Background – Introduction to **Remote sensing** – The (very) basics.

SIR-2: 'How does it all work?' – Colourful schematics and cartoons of the inner workings of the SIR-2 spectrometer, including a 'in depth' section.

Official **Logos**

MPS
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Sonnensystemforschung

LUNAR SCIENCE – *Why we want more*!

View 1 - (some) man on the street:

"...ohh, what's the point of still spending money on the Moon, it's boring, black & white, being there, done that...".

View 2 – Planetary scientists:

"…The Moon is the most accessible planetary laboratory currently at our disposal; its surface preserves a record of igneous activity, meteorite impact and solar wind flux dating back to the origin of the solar system…".

- Ah, the Moon. Great minds of the past have looked at it and speculated over its significance and influence on human lives and destiny, its origin, composition and nature. It has even entered our daily vernacular with words such as 'lunatic', associating its presumed (often negative) influences (and predictable changes in phases) with certain vagaries of human moods and conduct. Spiritual believers have historically elevated this celestial body to the Olympus of divinities, second only to the all mighty Sun. But its effect on mankind and life on Earth in general is far greater than quackologists /astrologists would lead us to believe. Put it bluntly, life probably would have not stood a chance to evolve past its most simple stages if the Earth had no moon: it stabilised our orbit and precession (so no wildly climate shifts like on Mars), shielded us from (many life-erasing) major impacts, created tides (harbouring early life forms?), illuminated our nights, given us our early calendars and werewolves…, no, just kidding, but you've got the idea. And the list goes on.

After a dozen of Americans have walked the (lunar) walk and returned hundreds of kilos of rock samples, telescopes and satellites observed its surface in great detail, you might be excused to think that, well, there isn't much more we need to know about the Moon. In reality we have only scratched the surface (oh dear…). But you see, science has this annoying habit of raising more questions the more we answer. For instance, we are still not sure about the mechanisms of its formation and evolution, why most of the exposed mare is on the nearside, if it has a core and what it is made of, if there is water ice at the poles, etc. There are also 'mysterious' outgassing episodes, deep moonquakes, unexplained flashes of light, goblins… sorry, no goblins, I got carried away again… Finally, let's conclude with a (true) platitude: "knowing the Moon is the key to understand our world". Well, there you go. -

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ORIGIN and EVOLUTION of the Moon – *Our (rather simplified) present model*

ORIGIN - Around 4.5 billion years ago, the giant impact between a Mars-like body and a young Earth would have thrown a vast amount of vaporised rock material into orbit.

Within a matter of weeks, these cooled rock particles would have accreted by gravitational forces into a sizable planetary body. The 'proto'-Moon was born.

'Phase 1' - During this accretion phase, because of the nature of the physical processes involved, the whole crustal layer would have been molten (a magma ocean); as it gradually cooled, different minerals would have solidified and settled differentially, according to their relative 'weight' and melting point temperatures, forming discrete geological strata.

'Phase 2' - Consequently, the uppermost layer of the Moon would have ended up with the 'lighter' type of rock (both in terms of density and colour...), that we call anorthosite (the present white regions of the Moon). This primordial solid crust would have continued being pounded and remixed by a relentless shower of various space debris including asteroids and comets.

This phase probably peaked around 4.3-3.9 billion years ago, when most of the giant basins of the Moon were excavated.

The highlands of the Moon (so called because of their higher elevation than the low-laying maria) today bear witness of the violent environment in the early stages of the solar system life.

The Earth also underwent a very similar bombardment, but the record of this phase has been mostly erased by the very nature of our dynamic and ever changing planetary surface.
This is one of the reasons why the Moon is so important to planetary science (and Earth science): it still shows the 'scars' of our planet 'birth'.

'Phase 3' - Back to the giant impacts: millions of years after their excavation these craters would have been infilled by locally erupted, extra-fluid magmas, originating from deep sources within the 'heavier' rock layers.

Mare volcanism appears to have peaked between 3.8 and 3.9 billion years ago.
These basaltic fields can be observed with the naked eye as the 'black' regions of the Moon.

Since then, the Moon (as the rest of the Solar System) has witnessed a gradual decline of comet and meteoritic impacts. Nevertheless, a relentless 'rain' of micrometeorites and cosmic particles still contintues today, further breaking down lunar surface materials to dust size grains and generating various impact materials

FUTURE - After nearly a generation, lunar exploration has returned to the scientific agenda, with many nations involved in new missions to our nearest neighbour.

The United States has affirmed its intention to a manned settlement on the Moon from 2025, and China has recently publicised ambitious plans for manned lunar activity circa 2020.

Japan, India, Germany, China, Russia, Britain and the USA have also sent or planned to send robotic probes to both orbit and land on the Moon over the next decade."

REMOTE SENSING – *a summary introduction*

"In remote sensing, electromagnetic radiation is employed as a tool to investigate matter and its properties."

"Planetary science relies heavily on this type of data to study otherwise inaccessible geological landscapes."

WHAT WE SEE ON EARTH - We know that sandy beaches are not the same everywhere: some are bright white, yellow, grey, or even black. This is because the principal constituent grains are different in each case: in yellow sands, for instance, we find the off-white quartz as the main mineral component; in black sands, volcanic rocks are probably the main source material.

ON THE MOON - Well, near the whole of the Moon is covered with a thick layer of rock debris, called regolith: as on a beach on Earth, sunlight is absorbed, scattered, radiated, and reflected off the lunar surface depending on the particular mix of minerals and materials present.

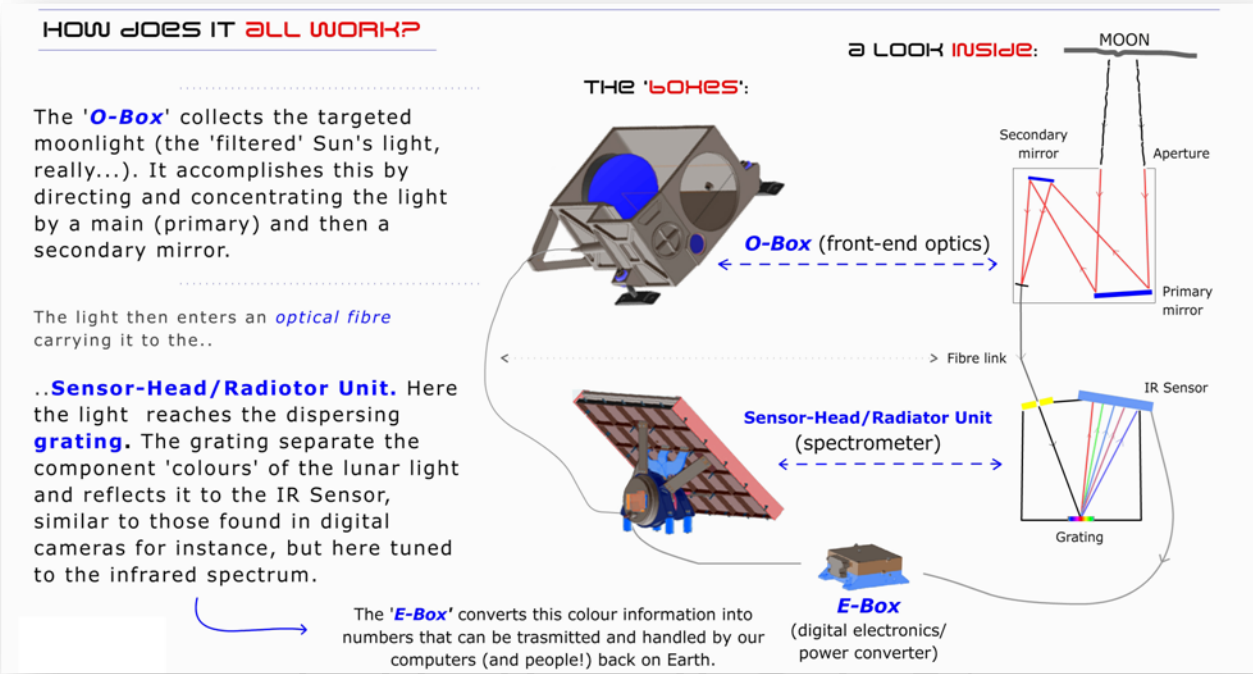
Unfortunately, because of the complex mix of minerals, glasses, and grain sizes the Moon looks decisively in… Black & White! But fear not, there is more to light that the eye can see... You remember at school, ordinary light from the window separating into a rainbow of colours after exiting a prism?

THE SPECTRA - Now, not only our eyes can't tell 'mixed' colours apart, but they can only see a very narrow range of colours too (red to violet)! UVs and x-rays are beyond our sight range, but we know they are there when we get sunburned or look at broken bones!

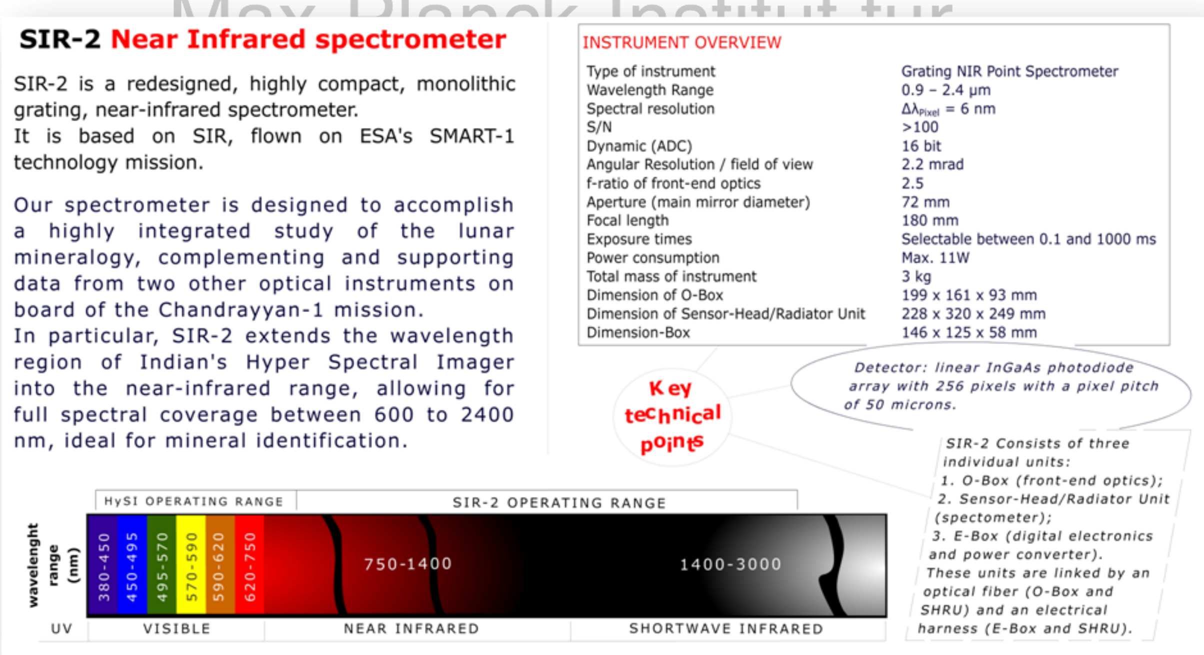
A spectrometer, like our SIR-2, allows us to separate the colour components of light ('make a rainbow'...) and carry out comparisons with known colour 'blends' (like 'fingerprints'), each characteristic of certain minerals mixes, even if these 'fingerprints' lie outside our senses.

In the case of SIR2, we look at the range of frequencies in the infrared, so called because it lies beyond the visible red hue.

SIR-2 - *Schematics and workings*



SIR-2 - *Further background and details*



LOGOS

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SIR2

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