PROPOSAL FOR 32-M TELESCOPE AT MEDICINA

ISTITUTO DI RADIOASTRONOMIA

The Director
Via P. Gobetti 101
I-40129 Bologna (Italy)

TITLE

Research on the Lunar Attenuation and Tiny Ionosphere
by exploiting the occultations of the European spacecraft SMART-1.

Principal Investigator:

Claudio Maccone
INAF / Int. Academy of Astronautics
Via Martorelli, 43
10155 Torino (Italy)
Tel: 011 2055387 Mobile: 347 1053 812
Email: clmaccon@libero.it

Other Investigators (name, institution):

Stelio Montebugnoli (INAF-IRA);
Salvatore Pluchino (Visiting Research Fellow);

Expected observer(s) Maccone, Pluchino

Is this a resubmission of a previous proposal? no (X) yes( ) – proposal number(s): ……..
Is this a continuation of (a) previous proposal(s)? no (X) yes( ) – proposal number(s): ……..
Is this part of a Ph.D. project? no (X) yes( ) – Student's Name: …….

Hours requested for this period: **26**

LST range(s):	from: 08h08m15sto: 16h09m34s	date: 26 Aug, 2006
	from: 09h21m23sto: 16h22m32s	date: 27 Aug, 2006
	from: 10h35m31sto: 16h36m30s	date: 28 Aug, 2006
	from: 11h52m39sto: 16h53m29s	date: 29 Aug, 2006

Number of hours foreseen for full completion of this proposal: ……. of which ……. were already allocated

Receivers:

Primary focus: 1.4GHz ( ) 1.6 GHz ( ) 2.3 GHz (X) 8.3 GHz ( ) 22 GHz ( )
Secondary focus: 5.0GHz ( ) 6.0 GHz ( ) 6.6 GHz ( )

Backends:

Continuum backend ( ) ARCOS ( ) digital spectrometer (X) polarimeter ( ) pulsar backend ( )
Guest instrument ( ) specify: ……

ABSTRACT

The existence of a tiny lunar ionosphere was suggested since the 1950's/60's during the radio observations of some lunar occultations. Nowadays, the SMART-1 European spacecraft, launched by ESA in 2003 and currently in orbit around the Moon, provides a wonderful opportunity to investigate again the tiny lunar ionosphere directly as well as the ATTENUATION of radio waves beside (and behind) the Moon. In fact, the radio waves emitted by SMART-1 around the frequency of 2235.1 MHz (S-band) will be crossing the lunar ionosphere completely whenever the probe starts hiding behind the Moon and whenever it re-emerges on the other side. We would like to take this opportunity of SMART-1 spiralling along decreasing orbits around the Moon (until it finally crashes on the lunar surface around September 3rd, 2006) to gather a HOST OF DATA about the intensity, phase and polarization of the incoming S-band waves that have crossed the lunar ionosphere. Later data reductions are expected to provide us with the refraction index and the radial decreasing electron density of the tiny lunar ionosphere, that may also change according to the position of the Moon with respect to the Sun and the magnetic tail of the Earth. A good theory of the lunar ionosphere and lunar signal attenuation would then hopefully emerge.

Scientific Justification

The radio occultation technique to sound planetary atmospheres using spacecraft began almost at the dawn of the era of planetary exploration. In 1964 the Mariner 4 spacecraft was the first to pass behind Mars as viewed from Earth. The carrier phase delay and amplitude variation observed in the radio link between Mariner 4 and the Earth-based radio telescopes provided valuable information about the density of the tiny Martian atmosphere and ionosphere.

As for the Moon, the existence of circum-lunar plasma was suggested in 1950's/60's during the radio observations of the lunar occultations used to determe the positions of cosmic radio sources. In fact, the measured positions of radio sources often differed from the ones found for the optical and higher radio frequency range, and the explanations of those shifts was the refraction of radio waves in the Moon ionosphere. The first lunar radio occultation with Pioneer-7 (1966) revealed a plasma cloud above the Moon surface with an electron density smaller than 4×10^7 el/m^3. A few years later, the dual frequency measurement realized by the Russian spacecraft "Luna-19" and "Luna 22" provided evidence for the existence of the plasma regions with TEC (Total Electron Content) close to $4x10^{14}$ el/m^2 at heights up to 10 km. Later, these results were explained as the probable effect of the lunar photoelectron layer.

The SMART-1 radio occultation experiment here proposed (to take place in August 2006) could give us another opportunity to investigate the plasma near the Moon using the powerful method of radio occultation. The experiment refers to a sounding technique in which a radio wave from an emitting spacecraft passes through an intervening planetary atmosphere before arriving at the receiver. The receiver measures the phase and amplitude of the wave over the duration of the occultation event. The phase and amplitude of the wave at the receiver consequently are altered relative to their values that they would have without the intervening medium or the occulting planet. During a lunar radio occultation of SMART-1, as long as time evolves, profiles of the phase variation and the amplitude variation will be generated and recorded by the ground based radio astronomical station. These profiles will provide us information about the refractive properties of the intervening medium. The accuracy of the occultation measures will be limited by the screening effect of the Earth's ionosphere and the solar wind plasma. Because of this, we propose to observe the SMART-1 radio occultations while the Moon altitude is greater than about +20°. Also, because of the synchronous rotation of the Moon around its axis, only the area in the vicinity of the lunar limb is accessible. And the sizes of the area to be investigated are defined by the libration of the Moon in latitude and in longitude and by the number of SMART-1 orbits around the Moon within the 4-days observational period here proposed. The SMART-1 spacecraft now (March 2006) is orbiting around the Moon with a period of about 5 hours, but at the moment we cannot know the orbital period that the S/C will assume during the last week of August, just few days before it crashed on the Moon (tentatively, on September 3rd, 2006). Because of these reasons our proposal would ask the use of the 32-m parabolic antenna to produce 26 hours of observations distributed in 4 days (26-27-28-29 August 2006) as follow:

Date	Start Obs.		Stop Obs.		Session
	UT	LST	UT	LST	duration (h)
Aug 26, 2006	09:05	08:08:15	17:05	16:09:34	8
Aug 27, 2006	10:14	09:21:23	17:14	16:22:32	7
Aug 28, 2006	11:24	10:35:31	17:24	16:36:30	6
Aug 29, 2006	12:37	11:52:39	17:37	16:53:29	5

Tab.1 – Proposed sessions to measure the SMART-1 radio occultations in S-Band.

These measurements are important for the understanding of the physics of the lunar atmosphere and also for radio frequency astronomical observations from the future lunar based stations. Because the increasing RFIs on the Earth, the future of (mainly) low frequency radio astronomy is space-based and Luna-based, as described in the following peer-reviewed papers published by the Principal Investigator:

1) C. Maccone, "The Quiet Cone Above the Farside of the Moon", Acta Astronautica, Vol. 53 (2003), pages 65-70.
2) C. Maccone, "Moon Farside Radio Lab", Acta Astronautica, Vol. 56 (2005), pages 629-639.

We would like to thank the INAF/IRA Time Allocation Committee for their consideration of this astronomical and astronautical Proposal.
We also are grateful to Prof. Cesare Barbieri, Ing. Stelio Montebugnoli and Dr. Simona Righini for they very helpful initial support to outline this innovative research.
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Sincerely yours

Claudio Maccone, Ph. D. (home page: http://www.maccone.com), Principal Investigator.
Salvatore Pluchino, Co-Investigator.