PROPOSAL

for research project "Nuclear Planetology"

in the International Space Science Institute for the call of 2007

Abstract. We propose the research project "Nuclear Planetology" to address to the main subjects, current development and recent findings of this new field of space science in application to past, current and future space missions. Six inter-related major goals of the project include (1) review of mapping for celestial bodies of their nuclear emission and of distribution of chemical elements, (2) study of concepts of perspective advanced telescopes of neutrons and gamma-rays for remote sensing of Moon, Mars, etc. for adequate mapping for districting geological, mineralogical and geochemical types of surface materials, (3) study of methods of active neutron measurements for determination of composition of surface material from landers on celestial bodies, (4) review the methods of nuclear data deconvolution from orbit and from the surface for determination of elementary composition of the celestial body, (5) determination of the requirements for development of nuclear physics for needs of accurate analysis of nuclear data from celestial bodies and (6) To review nuclear cosmogenic processes in the surface material of celestial bodies under the action of galactic cosmic rays and solar particle events.

Scientific rational, goals and timeliness of the project

Since several first pioneering measurements of nuclear emission from the Moon (J. Arnold and J. Trombka with colleagues, about 40 years ago) and Mars (C. d'Uston and I. Mitrofanov with colleagues, about 20 years ago), we are participating now at the period of fast expansion of nuclear methods in planetology. The main reason for that expansion is the unique ability of the nuclear physics to measure by the most direct way the fractions of most nuclei in the soil of the celestial bodies, and, therefore, to determine the content of soil constituting elements, the content of natural radioactive elements, the fraction of cosmogenic nuclides, etc. These data contain the essential knowledge on the origin of particular celestial bodies, on the processes of surface creation and evolution, and on the presence of hydrogen, hydroxyl and water in the soil.

The current data from the Gamma-Ray Spectrometer suite from NASA Mars Odyssey has successfully demonstrated the research power of nuclear methods for Mars exploration: actually, the data from GRS has completely changed the previous paradigm of Mars cryosphere and hydrology. At the present time, several missions with nuclear instruments are in the cruise flight to the next research target (NASA's Messenger to Mercury), are ready for launch in 2007 (NASA's Dawn to Ceres and Vesta and the Japanese Selene to the Moon), or are at the development stage (NASA's Lunar Reconnaissance Orbiter – LRO for Moon, ESA's BepiColombo for Mercury, Russian Phobos-Grunt for Phobos and NASA's Mars Science Laboratory - MSL for Mars).

We propose this project to adequate respond to problems and challenges of the currently expanding field of space science: ***nuclear planetology***. The ***scientific rational*** of this project combines the development of two complementary sides of this progress:

(a) development of nuclear methods and instruments for space science applications, and

(b) definition of problems and investigations of celestial bodies that are the most appropriate for studies by the methods of nuclear science.

For accomplishing aspect (a), one needs to have nuclear physicists; for development of aspect (b), one needs planetologists. The idea of the proposed project is to integrate into one study team

the world level scientists, which have the highest professional ability to contribute to the both sides of this progress, (a) and (b), for creation the vision of new horizons and perspectives of nuclear planetology in the future.

Therefore, scientific goals of the proposed project are the following:

Goal (1) "Surface Mapping": To review the presently available data of orbital mapping of gamma-ray and neutron emission of Moon (using Luna, Apollo and Lunar Prospector data), Mars (using Odyssey data) and Eros (using NEAR-Shoemaker data); to discuss the current problems of data transition from the level of physical counts in the instrument toward the upper level of maps of chemical elements on the surface. Some results using nuclear radiations will be compared with the data from other observations, such as the seasonal deposition of carbon dioxide on Mars surface inferred from laser altimetry and gravity measurements, or data for thermal inertia and surface albedo for sunlight, to determine the new knowledge from different sets of data, or to study areas of inconsistency and uncertainty in data from different instruments and methods.

Goal (2) "Perspective Telescopes": To study the concepts of perspective advanced detection systems for the remote sensing of neutron and gamma-ray emission of Moon, Mars, Vesta, Ceres, Mercury, Europa, Enceladus, etc. with better sensitivity and higher spatial resolution in accordance with the requirements for adequate mapping for distincting geological, mineralogical and geochemical types of surface materials. Methods of minimizing the effects of backgrounds in such instruments will also be examined.

Goal (3) "Neutron Activation Methods": To study the methods of active neutron measurements for determination of composition of surface material from landers on the surface of an celestial body; to determine the concept of scientific instrument for the analysis of gamma-rays and neutrons produced by neutron activation; and to discuss the strategy of active neutron experiments on the surface of Moon and Mars.

Goal (4) "Nuclear Data Analysis": To review the methods of nuclear data deconvolution from orbit and from the surface for determination of the elementary composition of the celestial body and for testing the layering structure of shallow subsurface; to consider possible biases and errors of these methods for accurate determination of soil composition, for surface imaging from the orbit, and for resolution of depth-dependent structure of the subsurface.

Goal (5) "Requests to Nuclear Physics": To determine the requirements for development of nuclear physics for needs of accurate analysis of nuclear data from celestial bodies from nuclear instruments; to consider the accuracy the data for nuclear cross sections, and to compare modern versions of numerical codes for Monte Carlo calculation of nuclear processes.

Goal (6) "Cosmogenic Processes": To review nuclear cosmogenic processes in the surface material of celestial bodies under the action of galactic cosmic rays and solar particle events, including the modeling of such processes; and to discuss the implications of such in situ data for the analysis of surface origin and evolution.

For each of these six goals, the joint work will mainly focus on open questions of the current state of the field, on problems of data analysis and interpretation, and on the potential directions of further development. The team does not plan to design new instruments or methods for data analysis in the content of this project, but to perform the comprehensive analysis of current progress in this directions to develop the joint vision of the entire field.

The key idea of the presented project is the development of all these six goals in the united process of studies and discussions. We know from our practical experience how much the problems related with each if these goals are interfering with problems of another one – and we know that no one may address to all of them by the individual efforts. That is why we suggest this project for ISSI, as the road to get this integrated vision on rapidly developing field of nuclear planetology – and to share one findings with the community.

List of expected outputs

Each team member of this proposed project is an active researcher in some particular field of nuclear planetology, and each of us regularly publish research papers on the particular subjects. But we believe that our joint work on this project will provide for us the excellent opportunity for unification of our individual researches into the broad vision, which would combine the picture of general perspectives with the accurate description of main details. Therefore, we expect to produce two major products from this project:

(I) Review paper: All discussions of topics related with goals (1) – (6) will be presented in the special review paper in Space Science Review or in another similar journal. Actually, this paper should be analysis of the current state of the field, rather than comprehensive review of all known particular researches. We plan to provide the general overview of current instruments, methods and results for determination the most important tasks and problems for further development in future.

(II) Research papers: We understand that open and detailed discussion of particular subjects during the project implementation will produce joint ideas and findings, which will become the subjects of particular research papers. Therefore, we expect writing of 2 – 3 research papers on some particular subjects or topics of goals (1) – (6).

What added value does ISSI provide for implementation of this project

Team members of this proposed project have all necessary research, computation and communication facilities in the home institutions. The main role of ISSI on this project is the hosting of three one-week meetings of the project team and some key experts. On the other hand, we would be very much pleased to have colleagues from ISSI research staff at our meetings. We also will be happy to consider the options of one bi- or multi-lateral combined meeting with another research team (or teams), which subject could be of joint interest for all participating teams.

List of confirmed participants

The List of confirmed participants is the following (see also short CVs in the Appendixes 1 - 8):

	Name	**Area of science expertise relevant to this project**	**Affiliation**
1.	Prof. William Boynton	Team leader and member of nuclear experiments on Mars Odyssey, Messenger and LRO. ***Areas of expertise:*** development of nuclear instruments, nuclear data analysis, physics and chemistry of soil of celestial bodies based on nuclear data (relevant to goals (1), (2), and (4))	University of Arizona, Tucson, USA
2.	Dr. Johannes Brueckner	Team member of nuclear experiments on NEAR, Mars Pathfinder, MER, Mars Odyssey and Rosetta Lander. ***Areas of expertise:*** physics of X-ray and gamma-ray	Max Plank Institute fuer Chemie,

		detection, nuclear data analysis and geochemical interpretation (relevant to goals (1), (2), (4), and (5))	Mainz, Germany
3.	Dr. Maxim Litvak	Team member of nuclear experiments on Mars Odyssey, LRO, MSL, BepiColombo and Phobos-Grunt. ***Areas of expertise:*** development of nuclear instruments, neutron data deconvolution, estimation of seasonal deposition of carbon dioxide on the surface of Mars from neutron data (relevant to goals (1), (3), and (4))	Institute for Space Research, Moscow, Russia
4.	Dr. Igor Mitrofanov, - team coordinator	Team leader and member of nuclear experiments on Mars Odyssey, LRO, MSL, BepiColombo and Phobos-Grunt. ***Areas of expertise:*** development of nuclear instruments, neutron data deconvolution, estimation of hydrogen content in the soil (relevant to goals (1), (2) and (3))	Institute for Space Research, Moscow, Russia
5.	Prof. Robert Reedy	Team member of nuclear experiments on Apollo, NEAR, Mars Odyssey and Selene, PI for cosmic-ray interactions ***Areas of expertise:*** theoretical modeling of cosmic-ray-induced nuclear interactions in and emission from planets, accuracy of nuclear data, (relevant to goals (4), (5) and (6))	University of New Mexico, Albuqerque,USA
6.	Prof. Roald Sagdeev	Team member of nuclear experiment on LRO and Phobos-Grunt. ***Areas of expertise:*** physical process and nuclear interactions in the surface of celestial bodies under bombardment by cosmic rays (relevant to goals (2) and (6))	University of Maryland, College Park, USA
7.	Dr. Jack Trombka	Team member of nuclear experiments on Apollo, NEAR, Mars Odyssey, LRO. ***Areas of expertise*** – analysis of surface composition from the nuclear data, systematic errors and biases of nuclear data deconvolution, methods of imaging in neutron and gamma-ray observations (relevant to goals (1), (2), and (3))	NASA, Goddard Space Flight Center, Greenbelt, USA
8.	Dr. Claude d'Uston	Team member of nuclear experiments on Mars Odyssey, MER, and Selene, Rosetta Lander, Phobos-Grunt. ***Areas of expertise*** – physics of gamma-ray and neutron detectors, analysis of energy spectra of nuclear lines for estimation of content of elements in the soil (relevant to goals (1), (2), and (5))	CESR, Toulouse, France

We also plan to invite to each team meeting several (~4) key experts in the areas of particular topic of the meeting. Preliminary list of these people is presented below:

Dr. Tom Prettyman	Los Alamos National Laboratory, United States
Dr. Nobuyuki Hasebe	Waseda University, Japan
Dr. Jitendra Goswami	Physical Research Institute on Ahmedabad, India,
Dr. Johannes Geiss	University of Bern, Switzerland
Dr. Lucy Lim	Goddard Space Flight Center, United States
Dr. Beboit Pirard	University of Bern, Switzerland
Dr. Richard Starr	Catholic University, United States
Dr. Larry Evans	Computer Science Corporation, United States
Dr. Valery Schvetsov	Joint Institute for Nuclear Research, Russia
Dr. Georg Weidenspointner	CESR, France

Schedule of the proposed project

Proposed project will have duration of 18 months with start at September 2007 and will end in February 2009. Three meetings of project team are suggested:

Time of meetings and events	Tasks for event and for meeting	Comments
Start: September 2007	Definition of final program of Meeting #1. Preparation of talks and discussions. Arrangements for travel and accommodation	Team coordinator in correspondence with ISSI
Meeting #1: 1 week, Oct.-Nov. 2007 (72 men·day)	***Tentative subjects of Meeting #1:*** 1.1 "Surface mapping by neutron and gamma orbital instrument, data analysis, determination of surface structure and composition" (relevant to goals (1), (4)) 1.2 Discussion of content of the review paper	Experts shall be invited from missions like Lunar Prospector, plus planetologists
Meeting #2: 1 week, Apr.-May 2008 (72 men·day)	***Tentative subject of Meeting #2***: 2.1 "Requests to Nuclear Physics from needs of nuclear planetology: reference data for cross-sections, methods of numerical calculations (relevant to goal (5)) 2.2 "Cosmogenic Interactions" (relevant to goal (6)) 2.3 Discussion of drafts for the review paper for sections relevant to goals (1), (4), (5) and (6)	Experts will be invited from nuclear physics and cosmic-ray interactions
Meeting #3: 1 week, Oct.-Nov. 2008 (72 men·day)	***Tentative subject of Meeting #3:*** 3.1 "Perspective instrumentation for nuclear planetology" (relevant to goals (2) and (3)) 3.2 Discussion of drafts for the entire review paper	Experts will be invited with the experience of nuclear instrumentation
End: February 2009	Submission of the review paper and research papers, creation of final report for ISSI	

Facilities Required

No special facilities are required from ISSI for accomplishment of this project. Ordinary conditions for the meetings - meeting room, video beamer, photocopier and internet – shall be sufficient for our work in ISSI.

Financial support requested for ISSI

We are requesting for these project to support three team meetings (see Table) with the total cost for accommodation equal to 216 men·day (assuming 12 participants at each meeting with 6 days stay in Bern).

We also expect secretary and administrative support of this project from ISSI, which cost could be determined by ISSI according to internal expenses.

Appendix 1

WILLIAM V. BOYNTON

University of Arizona
Lunar and Planetary Science Lab, SSB #92
1619 E. University Blvd., Tucson, AZ 85721, USA

EDUCATION

1966	B.A. Chemistry, Wesleyan University Middletown, Connecticut
1971	Ph.D., Physical Chemistry, Carnegie-Mellon University Pittsburgh, Pennsylvania

ACADEMIC AND PROFESSIONAL APPOINTMENTS

1966-71	Research Assistant/Teaching Assistant, Carnegie-Mellon University
1971-74	Research Associate, Oregon State University
1974-77	Assistant Research Geochemist, University of California, Los Angeles
1977-81	Assistant Professor, Department of Planetary Sciences, University of Arizona
1981-87	Associate Professor, Department of Planetary Sciences, University of Arizona
1987-	Professor, Department of Planetary Sciences, University of Arizona

HONORS AND AWARDS

1966	Sherman Prize, Excellence in Mathematics, Wesleyan University
1980	Elected Fellow of the Meteoritical Society
1982	NASA Group Achievement Award
1984	National Research Council, Senior Research Fellowship
1993	NASA Group Achievement Award for Mars Observer Gamma-Ray Spectrometer Payload Development
2000	Computer World Smithsonian Laureate
2003	NASA Group Achievement Award for Discovery of Sub-Surface Ice on Mars
2004	NASA Public service medal for relating information on discovery of sub-surface ice on Mars.

RESEARCH INTERESTS

Cosmochemistry of the planets and primitive bodies via remote, in-situ, and laboratory analysis. These interests include studying the origin and evolution of the solar system from analyses of asteroids, comets, and primitive meteorites. They also include studying the origin and evolution of individual planetary bodies, especially Mars, Moon, asteroids and comets, via remote elemental analysis with gamma-ray and x-ray spectrometry, via in-situ analysis with differential scanning calorimetry and evolved-gas analysis.

PROFESSIONAL SOCIETIES

American Association for the Advancement of Science
American Astronomical Society, Division of Planetary Sciences
American Chemical Society
American Geophysical Union
Meteoritical Society
Sigma Xi

PROFESSIONAL SERVICE (selected)

1984-85	Group Chief, Lunar and Planetary Geosciences Review Panel
1984-86	Member, Space Science Board Study on Major Directions for Space Science: 1995-2015
1984-86	Chair, NASA/ESA Science Advisory Group - Subcommittee on Comet Missions
1984-93	Member, X-ray/gamma-ray Instrument Definition Science Team
1986-94	Team Leader, Mars Observer Gamma Ray Spectrometer Investigation
1986-90	Principal Investigator, Comet Penetrator-Lander, Comet Rendezvous/Asteroid Flyby Mission
1987-89	Member, Space Sciences Board, internationally cooperative Mars Sample Return Committee
1991-94	Member, Mars Environmental Survey (MESUR) Science Definition Team
1991-93	Member, Microrover Demonstration Science Advisory Group
1992-93	Member, Committee on Space Science Technology Planning, National Research Council
1992	Member, Planetary Flight Instrument Cost Workshop;
	Chair, Subcommittee on Instrument Selection Process
1993	Member, Lunar and Planetary Sample Team, NASA Advisory Committee
1993-95	Member, NASA Rosetta Advisory Group
1994-01	Team Member, Near-Earth Asteroid Rendezvous, GRS and XRS investigations
1995-99	Chair, Space Science Working Group, Association of American Universities
1995-96	Chair, Discovery Lessons-Learned Steering Group
1996	Member, Panel to Review the Explorer Program, National Academy of Sciences
1996	Organizer, New Technology for Sample-Return Missions-NMP Workshop
1997-	Principal Investigator, Gamma-Ray Spectrometer Investigation on the Mars Surveyor Orbiter 2001 Mission
1998-02	Member, COMPLEX, Committee on Planetary and Lunar Exploration of the Space Science Board, NAS/NRC Advisory Committee
1999	Co-Investigator, MESSENGER Discovery mission to Mercury, Chair of geochemistry group and responsible for data from the x-ray and gamma-ray spectrometers.
2004	Co-Investigator on NASA Phoenix Lander mission to Mars north polar region, responsible for the Thermal and Evolved-Gas Analyzer instrument.

March 2007

Appendix 2

CURRICULUM VITAE

Dr. Johannes Brückner

Max-Planck-Institut für Chemie
Department of Geochemistry
P.O. Box 3060
D-55020 Mainz, Germany

1949	Born in Mainz, Germany, Citizenship: German.
1977	Diploma in physics at Johannes-Gutenberg-University, Mainz, Germany.
1977 – 1978	Research associate at University of Kentucky, Lexington, KY, USA.
1979 – 1984	Ph. D. in physics at Johannes-Gutenberg-University, Mainz, Germany.
1984 – 1986	Post-doctoral fellowship at Max-Planck-Institute for Chemistry (MPCh).
1986 – 1988	Research assistant at MPCh , Dept. Cosmochemistry, Mainz, Germany.
1986 – 1989	Co-I of ALPHA-X experiment for Soviet Phobos lander.
1986 – 1991	Associated investigator for NASA's MARS OBSERVER Gamma Ray Spectrometer.
since 1988	Tenure position at MPCh, Dept. Cosmochemistry, Mainz, Germany.
1988 – 1996	PI of collaboration 'Radiation Damage in Solid-State Detectors' at accelerator SATURNE.
1990 – 1993	Co-I of NASA's Gamma Ray Spectrometer Investigation and Development Science Team.
since 1991	PI of collaboration 'Thick Target Proton Irradiations' at accelerator SATURNE.
1992 – 1993	Participant Scientist of NASA's MARS OBSERVER Gamma Ray Spectrometer.
1994 – 2001	Co-I of NASA's Near Earth Asteroid Rendezvous X/Gamma Ray Spectrometer.
since 1996	Participant Scientist of NASA's Mars Odyssey Gamma Ray Spectrometer.
1997 – 1998	Co-I of NASA's Mars Pathfinder Rover Alpha Proton X-Ray Spectrometer (APXS).
since 1997	Member of ESA's Mercury Science Advisory Group.
1998 – 2000	Member of ESA's Solar System Working Group.
since 1999	Co-I of ESA's Rosetta Lander Alpha Particle X-Ray Spectrometer (APXS).
since 2002	Participant Scientist of NASA's Mars Exploration Rovers 2003 APXS

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Appendix 3.

Maxim L. Litvak

Institute for Space Research
Profsojuzmaja 84/32
117997 Moscow
Russia

Current Position

2002 to Present – position of Senior Scientist in Space Research Institute, Project Science Manager in HEND experiment.

Laboratory of Cosmic Gamma Ray Spectroscopy, Space Research Institute, Russia, Moscow, 117997, Profsouznaya st. 84/32

Research Area

Physic of planets, gamma-ray, x-ray and neutron spectroscopy.

Relevant Experience

2002-Present – Position of Senior Scientist in Space Research Institute.
1998-2002 – Position of Junior Scientist in Space Research Institute.

Education & Degrees

B.S. 1990-1996:	Moscow Engineering and Physics Institute
Post graduate student. 1996-1998;	Space Research Institute
PhD. 1998, Astrophysics:	Space Research Institute
Doctor of Science, 2005, Astrophysics:	Space Research Institute

Professional History

Dr. Maxim Litvak is a senior scientist at Space Research Institute, Moscow, Russia. He has graduated Moscow Engineering and Physics Institute and has got his PhD degree on astrophysics at Space Research Institute in 1998. In 2005 he has got a degree of Doctor of Science for his investigations in Martian science (search for subsurface water ice and observation of CO_2 cycle from HEND/Odyssey data). Now he works in the institute in laboratory of cosmic gamma ray spectroscopy with responsibility for data analysis in area of gamma and neutron spectroscopy, management of environment and functional tests of equipment developed in the laboratory. In 2004 he was assigned as HEND Project Science manager with main activity concerns science processing of HEND/Mars Odyssey data and its preparation for delivery to PDS. In 2006 He was assigned as LEND/LRO instrument (US mission to Moon scheduled for 2008) Leading scientist and Project manager for DAN/MSL instrument (US landing mission to Mars scheduled for 2009). Dr. Maxim Litvak is the author or co-author of more than 30 scientific papers in referred

journals and more than 100 presentations at the various domestic and international science conferences.

Honors and Awards

2003- NASA Group Achievement Award for the Mars Odyssey 2001 GRS.
2004- NASA Group Achievement Award for the Mars Odyssey 2001 GRS

Professional Society Memberships

American Geophysical Union

Selected Publications

More than 30 refereed scientific publications in the areas of gamma-ray and neutron spectroscopy. The latest ones as a first author:

1. Litvak, M. L.; I.G. Mitrofanov, A.S. Kozyrev, A. B. Sanin, V. I. Tretyakov, W.V. Boynton, D. Hamara, C. Shinohara, R.S. Saunders Modeling of Martian seasonal caps from HEND/ODYSSEY data (2005) Advances in Space Research, 36, 11, 2156-2161.

2. Litvak, M. L., I. G. Mitrofanov, A.S. Kozyrev, A. B Sanin, V. I. Tretyakov, W.V. Boynton, N.J. Kelly, D. Hamara, C. Shinohara, R.S. Saunders (2006) Comparison between polar regions of Mars from HEND/Odyssey data, ICARUS, 180, 23-37.

3. Litvak, M. L., I. G. Mitrofanov, A.S. Kozyrev, A. B Sanin, V. I. Tretyakov, W.V. Boynton, N.J. Kelly, D. Hamara, C. Shinohara, R.S. Saunders (2007) Long term observations of southern winters on Mars: estimations of column thickness, mass and volume density of the seasonal CO_2 deposit from HEND/Odyssey data , JGR, Volume 112, Issue E3, CiteID E03S13

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Appendix 4

Dr. Igor G. Mitrofanov

Head of laboratory of space gamma-ray spectroscopy
Institute for Space Research (IKI),
Russian Academy of Science
Profsojuznaja 84/32
Moscow, 117810 Russia
Tel: 7 095 333 34 89
Fax: 7 095 333 12 48
Email: imitrofa@space.ru

Education:

Doctor of Science	-1989, Space Research Institute (IKI), Moscow, Russia
Ph.D. in Physics	-1975, A.F.Ioffe Physical Technical Institute, St.Petersburg, Russia
M.S. in Theoretical Physics	-1974, University of St. Petersburg, St.Petersburg, Russia

Experience:

1992 - Present:	Head of laboratory, Institute for Space Research (IKI), Moscow, Russia
1981 - 1992:	Senior Scientific Researcher, Institute for Space Research (IKI), Moscow, Russia
1975 - 1981:	Junior Scientific Researcher, A.F.Ioffe Physical Technical Institute, St.Petersburg, Russia
1972 – 1975:	Post-graduated fellowship for Ph.D., A.F.Ioffe Physical Technical Institute, St.Petersburg, Russia

Dr. Mitrofanov is involved in space science researches for over 35 years. His thesis research for degree of Doctor of Science (equal to US Professor level, 1989) involved the development of theory of generation gamma-ray radiation in space conditions. Presently he in working in two complementary scientific fields:

- in high energy astrophysics with the major focuses on astronomic sources of high energy gamma-rays and origin of cosmic gamma-rays bursts, and
- in the experimental nuclear planetology for determining elementary composition, in particular content of hydrogen, in soils of planets and moons without atmospheres.

From 1984 Mitrofanov jointed space science exploration program, as co-PI of Soviet-France space experiment ***APEX*** for Soviet "Phobos-1" and "Phoros-2" missions. This experiment has presented in 1989 the valuable data on Martian gamma-ray albedo. In 1989-96 Mitrofanov was nominated as PI of Russian-US experiment with US-made high purity Ge sensors for Russian-made instrument ***PGS*** for Russian "Mars-96" mission. This mission has failed in 1996 during the injection phase into the interplanetary cruise orbit. ***PGS*** was supposed to be the very first joint Russian-US space instrument for solar system exploration.

Since 1992 until now Mitrofanov closely cooperates with ***BATSE*** instrument team in NASA Marshall Space Flight Center and National Space Science and Technology Center (Huntsville, Alabama) for studying and interpretation of data for cosmic gamma-ray bursts from NASA "Compton Observatory". His statistical studies of ***BATSE*** gamma-ray bursts are based on new

innovative methods of bursts parameterization, which have allowed to determine the most generic properties of bursts: they are average emissivity curve, emission time distribution, cosmological invariant parameters, etc. In the present time Mitrofanov leads the project of comprehensive studies of ***BATSE*** un-triggered bursts using the probabilistic approach of Bayesian statistics.

From 1997 Mitrofanov leads the Russian experiment with High Energy Neutron Detector (***HEND***) for NASA mission "Mars Odyssey". This mission in operating now on orbit around Mars since launch in April 2001. ***HEND*** is Russian contribution to the Gamma-Ray Spectrometer suite, which also include gamma-ray detector and neutron spectrimometer. These three instruments have delivered in 2002 the pioneering data about existence of permafrost water ice in shallow subsurface at large provinces at moderate latitudes on Mars.

In 2003 and 2004 four new Russian experiments were selected for implementation under the leadership by Mitrofanov, as Principal Investigator on behalf of Federal Space Agency of Russia, which all are based on very positive experience obtained from HEND investigations on "Mars Odyssey".

- The first one is the Neutron Spectrometer (***NS HEND***) for measurements of neutrons and gamma-rays from the surface of Martian moon Phobos onboard Russian interplanetary probe "Phobos-Grunt" of Federal Space Agency of Russia (scheduled launch in 2009). This data will allow to perform the experimental comparison of soil composition for Phobos with the presently available data for Earth, Mars and Moon and to understand the origin of this moon of Mars.

- The second instrument is the Detector of Albedo Neutrons (***DAN***) for NASA large rover "Mars Science Laboratory" (scheduled launch in 2009). This Russian instrument will include pulsing neutron generator of 14 MeV neutrons and detectors to measure die away time profiles of albedo epithermal and thermal neutrons. This data will allow to perform the remote sensing of hydrogen content in the martian soil within 1-2 meters of subsurface along the trace of MSL motion and to determine to most interesting water-rich spots of detailed in-situ analysis of subsurface.

- The third instrument is Lunar Exploration Neutron Detector (***LEND***) for NASA mission "Lunar Reconnaissance Orbiter" (scheduled launch in 2008). This Russian instrument with NASA-funded co-Investigators will provide the global maps of neutron emission of the Moon with spatial resolution of 5 km (HWHM). For polar regions ***LEND*** will deliver the data for hydrogen content with the detection limit of 100 ppm, which will allow to test the presence of water ice deposits within permanently shadowed craters at lunar poles. This instrument will also measure neutron component of radiation environment on 50 km orbit around the Moon.

- The fourth instrument is Mercury Neutron and Gamma-ray Spectrometer (***MGNS***) for the ESA mission "BepiColombo" (scheduled launch in 2013). This Russian instrument with European co-Investigators will provide the energy spectra of neutrons and gamma-rays from Mercury for determining the elementary composition of regolith and for testing permanently shadowed polar spots for the presence of water ice deposits.

Mitrofanov is author and co-author of 114 scientific papers in refereed scientific journals. He is co-author of Springer Publ. Inc. book "Water on Mars". Under his scientific supervising 7 Ph.D. and 1 Doctor thesises have been successfully accomplished. In 2001 and 2004 Mitrofanov got two Awards from NASA Administrator and two Awards from the Council of Russian Space Research Institute for successful development in implementation HEND experiment onboard NASA "Mars Odyssey". In 2003 he was decorated by Sergey Korolev medal of Russian Space Federation for his achievements in the Russian space program. In 2004 the discovery of water ice permafrost on Mars by HEND investigation has been selected into the List of the Best achievements of Russian Academy of Science presented to the Government of the Russian Federation.

March 26, 2007

Appendix 5.

Curriculum Vitae - Robert C. Reedy

Institute of Meteoritics & Department of Earth and Planetary Sciences, MSC03-2050
University of New Mexico, Albuquerque, NM 87131-1126 USA
Tel. 505-277-0030 (W), 505-672-9519 (H); Fax 505-277-3577; E-mail rreedy@unm.edu

Education: B. A., Colgate Univ., 1964; Ph.D. (Chemical Physics), Columbia Univ., 1969.

Positions:
Sept. '69 – Sept. '72 Postgraduate Research Chemist, Univ. California, San Diego, La Jolla.
Oct. '72 – Apr. '02 Technical Staff Member, Los Alamos National Lab., Los Alamos, NM.
Apr. '02 – present Research Professor, Univ. New Mexico, Albuquerque, NM.

Major Relevant Professional Activities:
Lunar Sample Co-Investigator (Co-I), 1969-1976.
Apollo Gamma-Ray Spectrometer Experiment Co-Investigator, 1970-1974.
Lunar Data Analysis and Synthesis Principal Investigator (PI), 1974-1978.
Planetary Materials & Geochemistry/Cosmochemistry Principal Investigator, 1978-present.
Mars Observer/Odyssey Gamma-Ray Spectrometer Team Member, 1984-present.
SELENE Gamma-Ray Spectrometer Co-Investigator, 2005-present.
Publications (1968-3/2007): 93 refereed papers; 50 other papers; 265 abstracts.

Selected relevant publications, 2003-2007:

G. Weidenspointner, J. Kiener, M. Gros, P. Jean, B. J. Teagarden, C. Wunderer, R. C. Reedy, D. Attié, R. Diehl, C. Ferguson, M. J. Harris, J. Knödlseder, P. LeLeux, V. Lonjou, J.-P. Roques, V. Schönfelder, C. Shrader, S. Sturner, V. Tatischeff, and G. Vedrenne (2003) "First Identification and Modelling of SPI Background Lines," *Astron. Astrophys.* **411**, L113-L116 (plus 10-page on-line electronic table).

R. C. Reedy (2004) "Recent Advances in Studies of Meteorites Using Cosmogenic Radionuclides." *Nucl. Instrum. Methods Phys. Res. B,* **223:** 587-590.

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Appendix 6.

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Dr. Roald Sagdeev is Distinguished Professor of Physics at the University of Maryland and is also Director Emeritus of the Space Research Institute, the Moscow-based center of the Russian space exploration program.

Dr. Sagdeev, one of the youngest scientists ever elected a full academician of the USSR Academy of Sciences, first made his international reputation as a plasma physicist while at the Kurchatov Institute in Moscow, where he served as an advisor on fusion science to Igor Kurchatov. A pupil of Nobel Laureates, Lev Landau and Peter Kapitsa, Sagdeev's work on the behavior of hot plasma and controlled thermo-nuclear fusion (at the Kurchatov Institute of Atomic Energy) and later at the Institute of Nuclear Physics in Akademgorodok, Siberia, won him the Lenin Prize. Many years later this work was also recognized in the United States, when he won the American Physical Societies' highest award for his "unmatched contribution to modern plasma physics."

In 1973, Dr. Sagdeev became the Director of the Space Research Institute in Moscow. Under his direction, many important projects were realized, including the joint US-Soviet Apollo-Soyuz, the Venera series to Venus, as well as the international missions to Halley's Comet and later to Phobos, a moon of Mars. These last two projects were devised and implemented by Academician Sagdeev, in cooperation with up to eighteen countries—during a very complex time in Cold War relations.

Dr. Sagdeev has been elected a member of many national scientific academies and societies around the world, including the National Academy of Sciences (USA), The American Academy of Arts and Sciences (USA), the Royal Swedish Academy, the Royal Astronomical Society (UK), The Max Plank Society (Germany), The International Academy of Astronomics, the Hungarian Academy of Sciences, the Czech Academy of Sciences, and the Third World Academy. He was also the first Soviet scientist ever elected to the Vatican Academy of Sciences.

In addition to his scientific career and his work to promote international cooperation in science, Roald Sagdeev also played an outspoken political role during the first five years of *perestroika*. Elected to the Supreme Soviet in 1987, he served as a summit advisor to Mikhail S. Gorbachev and Eduard Shevardnadze at three summits: Geneva (1985), Washington (1987) and Moscow (1988). He also served as an advisor to Gorbachev on issues related to space. From 1987-1991, he served as a deputy in the USSR's Congress of People's Deputies, pushing a radical reform agenda.

In addition to the prestigious Maxwell Prize conveyed by the American Physical Society, Dr. Sagdeev has also received honorary degrees from many prestigious universities, including

UCLA, New York University, the University of Michigan, Toulouse University (France), The Technical University of Graz (Austria), to name a few.

Prizes

- Maxwell Prize (American Physical Society)
- Hannes Alufen Memorial Lectureship (Royal Swedish Academy of Sciences)
- Von Karman Lectureship Award (American Institute of Aeronautics and Astronautics)
- "Distinguished International Professor" (University of Maryland)
- "Distinguished Career in Physics"(Washington Academy of Sciences)
- Leo Scillard Award (American Physical Society)
- Italian Government prize "Science for Peace"
- Tate Medal (American Institute of Physics)
- "Personality of the Year" (France)
- Highest Soviet awards, including the Lenin Prize (1984) for his work in plasma physics and "Hero of Socialist Labor" for his leadership of the International Mission to Halley's Comet (1986).

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Appendix 7.

Jacob I. Trombka

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POSITION/BRANCH: Astrophysicist, Senior Goddard Fellow, Program Scientist, X-Ray/Gamma-Ray Facility Program, Astrochemistry Laboratory, Solar Systems Exploration Division, NASA/Goddard Space Flight Center

EDUCATION; 1952 B.S., (Physics), Wayne University; 1954 M.S., (Physics), Wayne University; 1961 Ph.D., (Nuclear Science), University of Michigan.

PROFESSIONAL SPECIALTY: X-Ray, Gamma-Rays and Neutron Spectroscopy Remote Sensing.

PREVIOUS POSITIONS: Adjunct Professor Geology, University of Maryland; Adjunct Professor of Law, Georgetown Law School; Program Manager, Manned Space Flight, NASA Headquarters; Senior Scientist, Jet Propulsion Laboratory

MAJOR PROJECT/SERVICE RESPONSIBILITIES:
Team Leader - Near Earth Asteroid Rendezvous (NEAR) Mission; Principal Investigator – NASA/National Institutes of Justice Space Age Teleforensics Program; Co-Investigator – Mars Surveyor '01 Gamma-Ray Spectrometer; Co-Investigator – MESSENGER Geo-chemistry Experiment; Co-Investigator Lunar Reconnaissance Orbiter LEND Detector system: Principal Investigator-US/Russian Antarctic Gamma Ray Balloon Flight Program; Project Scientist - Mars Observer, Gamma Ray, Remote Sensing Spectrometer Facility; Co-Investigator - Russian Mars '94 Mission; Member of Flight Investigation Team Mars Observer Remote Sensing Gamma-Ray, Spectrometer, Member of Instrument Design Science, Team X-Ray/Gamma-Ray Remote Sensing, Gamma-Ray Spectrometer; Member of NASA Comet Rendezvous Asteroid Flyby Science Working Group; Member of Mercury Orbiter Project Working Group; Member of the National Academy of Sciences Primitive Body Working Group (European and USA) on Cooperative Planetary Exploration Programs; Co-Investigator Gamma-Ray Spectrometer WIND Mission; Guest Investigator Gamma-Ray Spectrometer Solar Maximum Mission; Guest Investigator X-Ray Fluorescence Experiment Viking Mission; Member Terrestrial Bodies Science Working Group; Principal Investigator United States/Russian Program for the Development of Remote Sensing X-Ray and Gamma-Ray Sensing Techniques; Member Editorial Advisory Board, Nuclear Technology; Co-Investigator NATO Project on Non-Destructive Testing of Historic Monuments (Venice); Principal Investigator for Apollo-Soyuz Crystal Activation Experiment; Co-investigator Apollo Gamma-Ray Spectrometer; Co-investigator Apollo X-Ray Spectrometer.

AFFLIATIONS:
American Physical Society; Sigma Xi; and IEEE

HONORS AND AWARDS:

John Lindsay Award, Most Significant Scientific Achievement, Goddard Space Flight Center, 1972; Exceptional Scientific Achievement Medal, NASA, 1971; Group Achievement Award, Lunar Orbit Experiments Team, NASA, 1971; Group Achievement Award, Lunar Science Working Panel, NASA, 1973; Group Achievement Award, Apollo-Soyuz Experimenters Group, NASA, 1976; Group Achievement Award, NEAR, NASA, 2002; Group Achievement Award, Mars Odyssey 2001, NASA, 2004; Member of Sigma Xi; Outstanding Graduate, Nuclear Department, University of Michigan, 1979; Exceptional Scientific Achievement Award, Goddard Space Flight Center, 1993; Senior Goddard Fellows Program Award, 1994.

PATENTS:

"Neutron/Gamma Ray Methods for Mapping Distribution of Contamination in Building Materials", patent Number 4,483,817, November 20, 1984.

PUBLICATIONS:

Author of over 150 papers in the field.

BOOKS:

C. E. Fichtel and J.I. Trombka, "Gamma Ray Astrophysics, New Insight into the Universe", Second Edition NASA Reference 1386, October 1997.

Rester and J.I. Trombka, "High Energy Radiation Background in Space", ed. A. Rester, Jr. and J.I. Trombka, American Institute of Physics, New York, 1989.

I. Adler and J.I. Trombka, "Geochemical Exploration of the Moon and Planets," Physics and Chemistry in Space, 3, Springer Verlag, Berlin, Heidelberg and New York, 1970.

C. E. Fichtel and J.I. Trombka, "Gamma-Ray Astrophysics: A New Insight Into the Universe," NASA SP-453, 1981.

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Appendix 8.

Claude d'USTON de VILLEREGLAN

Date and place of birth : 11 May 1949, Carcassonne (Aude), France

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Education :
"Diplome d'Etudes Approfondies" in space physics : Toulouse University, 1972
"Doctorat de Specialite" in geophysics (option space physics) : Toulouse University, 1975
"Doctorat es Sciences Physiques" : Toulouse University , 1981

Positions :
February 1977-December 1977 : CESR, Toulouse, CNES fellowship
January 1978-July 1978 : SEL/ERL-NOAA, Boulder (Co.), CNES fellowship
August 1978-September 1979 : CESR, Toulouse, CNES fellowship
Oct. 1979-Sept. 1991 : CESR, Toulouse, CNRS staff member (charge de recherche)
October 1991-present : CESR, Toulouse, CNRS staff member (directeur de recherche)

Professional Activities :

Past activities : 1) *Experimental and numerical studies of interplanetary plasma processes* : large scale interplanetary plasma physics / solar wind – comet interaction and comet environment / space mission experiments and observations : PROGNOZ 2, PROGNOZ 5, ISEE 1 & 2, GIOTTO, WIND, CLUSTER II

2) *Planetary exploration* : mostly experimental studies of the surface elemental composition by means of nuclear methods (GRS, XRF, NS) / space missions : PHOBOS 2, MARS GLOBAL SURVEYOR, LUNAR PROSPECTOR (LDAP), and also MARS 98 balloon, ROSETTA-CHAMPOLLION;

Present activities : *Study of present and past states of planetary bodies based on space mission observations :* Co-I on Mars Odyssey (experiment GRS, PI : W.V. Boynton of LPL U of A, Tucson, USA), on ROSETTA LANDER (experiment APX-S, PI : R. Rieder of MPC, Mainz), on SMART-1 (experiment D-CIXS, PI : M. Grande of RAL, Didcot, UK), on MER A & B (experiment complement ATHENA, PI : S. Squyres of Cornell Un., Ithaca, USA).

Preparation of new investigations : on SELENE (experiment GRS, PI : N. Hasebe of Waseda University, Tokyo), on Mars Science Laboratory (experiment CHEMCAM, PI : S. Maurice of CESR, Toulouse), on CHANDRAYAAN (experiment CIXS, PI M. Grande, of University of Wales, Aberystwyth, UK).

Also :

- Member of various national and international scientific committees for Solar System exploration on Mars, on the Moon, on Mercury (most past)
-member of various advisory groups of CNES (past);
-member of various payload review teams for planetary mission (past);
-member of the Comité National de la Recherche Scientifique section " solar system and far universe"(1991-1995)

-member of the French research group for space plasma - GDR PLASMAE - (past).
-member of the « Mars committee » of the French national planetology program - PNP - (past)
-coordinator of INTAS project #96-2269, "Physical and engineering foundations of optimal cooling of HPGe gamma-ray spectrometers for low altitude satellites, planetary landers and deep space missions" involving French, German, Russian and Belaruss research centers.
-tutor of 4 Phd works and of numerous Master works.

Professional Societies : European Geophysical Union,

Over 65 refereed publications

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