International experiments of the Russian Academy of Sciences in the frame of the Space Weather Program

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Introduction

ИКИ

Sun - basic energy source in the solar system. The solar action, which determines sun-earth connections, includes the following factors:

- short-wave solar UV- and X-radiation;
- solar cosmic rays;
- solar wind and interplanetary magnetic field;
-the galactic cosmic rays, which compose the influence of interstellar medium, traditionally are examined together with the solar factors.

Introduction

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The total power of solar radiation is ~ 4. 10^{26} W. In the external space practically this entire the energy is emitted in the form electromagnetic radiation in the thin surface layer of the sun - to photosphere. The solar changeability, critical for the space weather and the sun-earth connections comprises the portions of the percentage of general energy flow.

Introduction

Total flux of solar radiation near the Earth is called *solar constant* and composes 1366 W/m^2. Practically entire energy is concluded in the continuous thermal emission of photosphere. Short-wave emission stays by the atmosphere, therefore it can be measured only on board the spacecraft.

Introduction

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Solar wind (flow of the plasma ~ of 10^9 kg/s, which escapes into the interplanetary space) and the short-wave ionizing electromagnetic radiation forms the plasma mantles of the Earth - magnetosphere and the ionosphere. Therefore besides the solar factors are examined also the conditions, created by the magnetosphere and the ionosphere:

- flows of the charged particles,
- electric currents,
- other sporadic phenomena

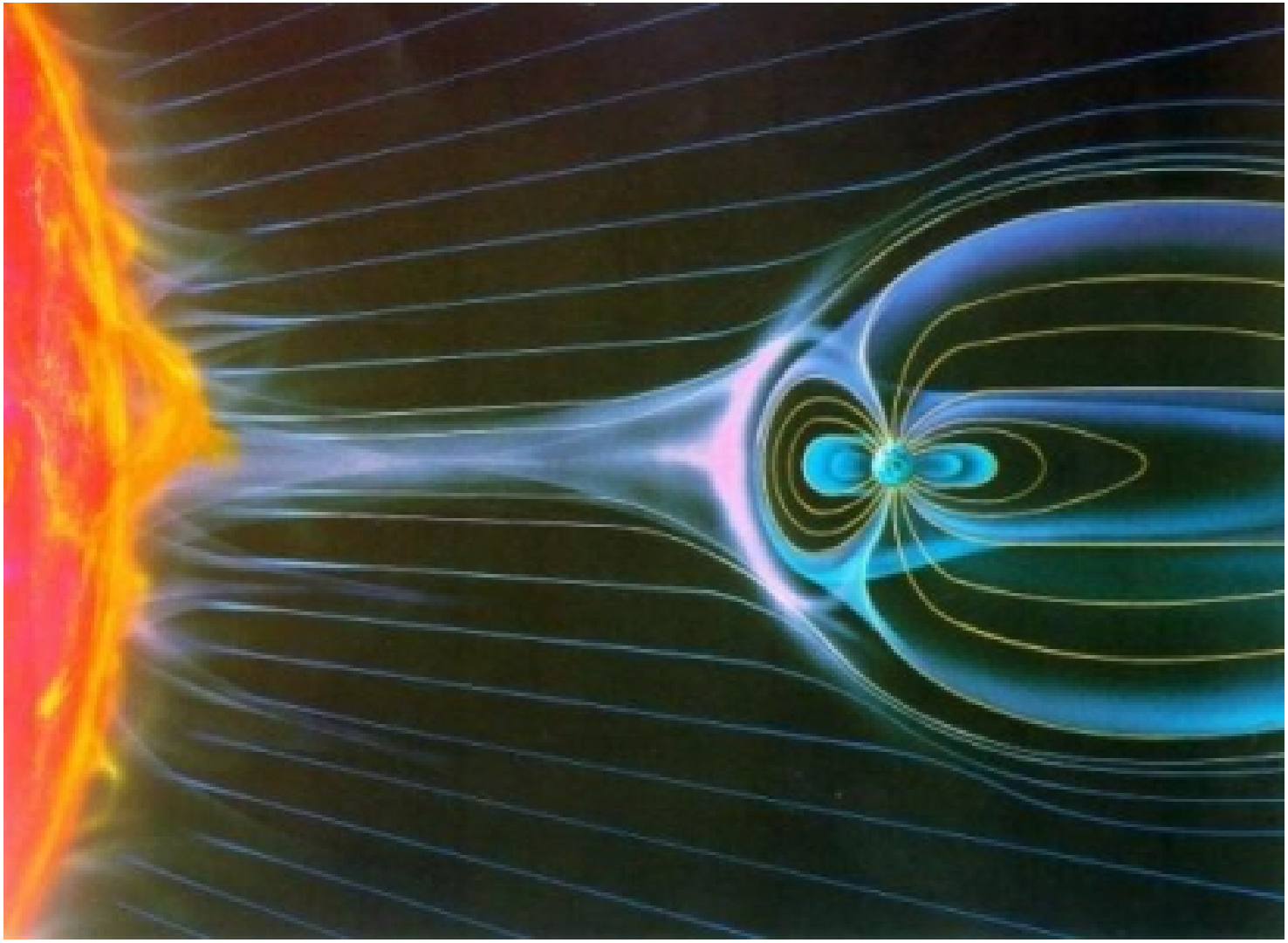
are connected with the explosive (eruptive) events to the Sun.

Introduction

The action in the entire chain of Sun-Earth connections it can be described as the anomalous strengthening by constant component, of different kind of storm - *magnetic*, *radiation*, *ionospheric*.

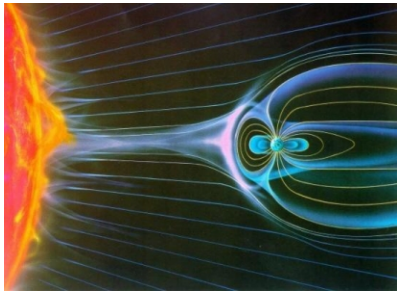
Introduction

Solar radio emission is also a good level indicator of solar activity. The flux of radio emission on the wave 10,7 cm (index $F_{10,7}$) correlates with the solar ultraviolet radiation and frequently it is used as the characteristic ionizing solar radiations.



Date: 09 Jul 2009 Satellite: Cluster Depicts: Copyright: NASA

Sketch of the interaction between the solar wind and a magnetized planet (e.g. Earth, Jupiter). The pinkish area on the Sun-side of the planet symbolizes the solar wind conversion into heat. In the case of magnetized planets, most of the solar wind is first decelerated from supersonic to subsonic speed when it crosses a boundary layer called a bow shock, located ahead of such planet. The Earth's bow shock is located at about one fourth the distance to the Moon in the direction of the Sun.



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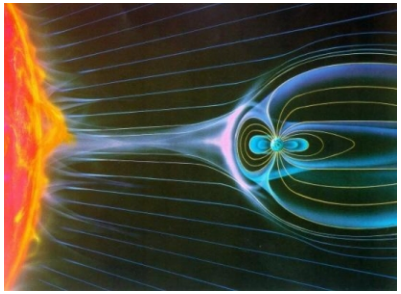
HISTORY

1. *CORONAS-I (launched on March, 1994).*
2. *INTERBALL-1 (launched on August, 1995).*
3. *INTERBALL-2 (launched on August, 1996).*
4. *CORONAS-F" (launched on July, 2001).*
5. *CORONAS-Photon" (launched on February, 2009).*



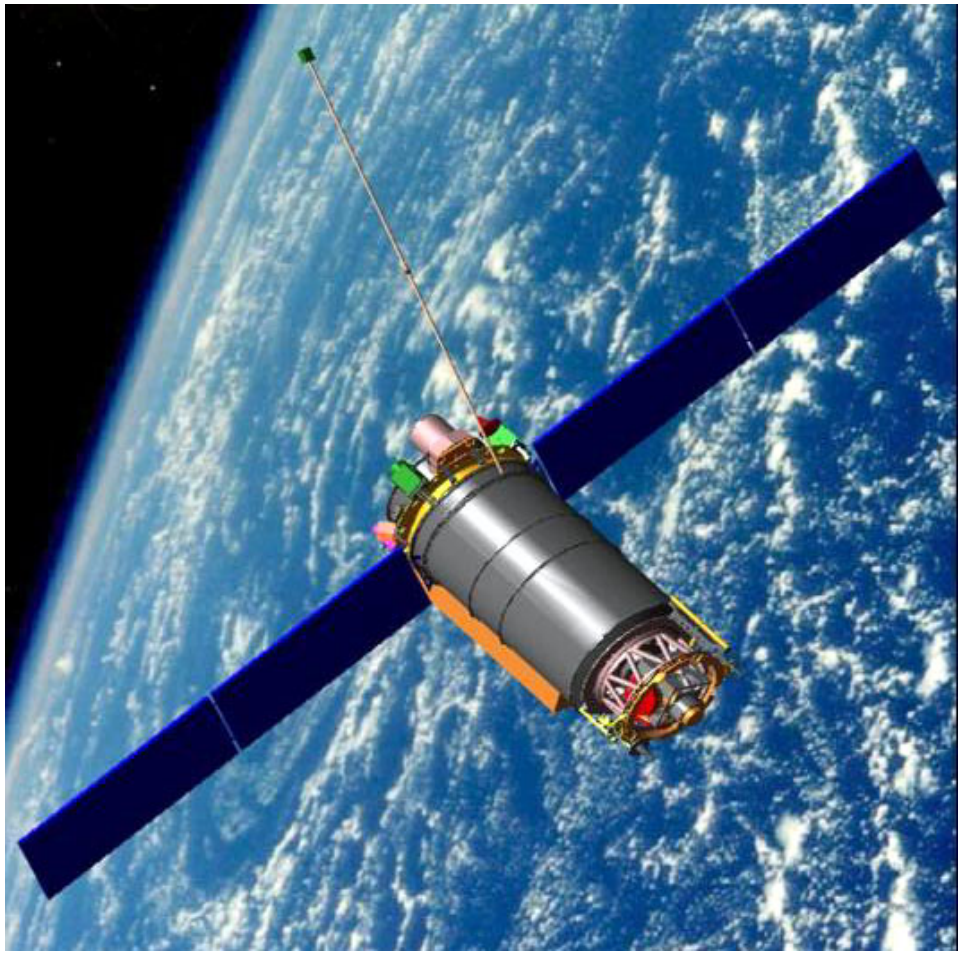
"CORONAS-PHOTON"

http://www.astro.mephi.ru/english/e_photon.htm

- solar UV- and X-radiation;
- solar cosmic rays;

The third mission in the satellite series of the "Coronas" project (two others are "Coronas-I" and "Coronas-F").

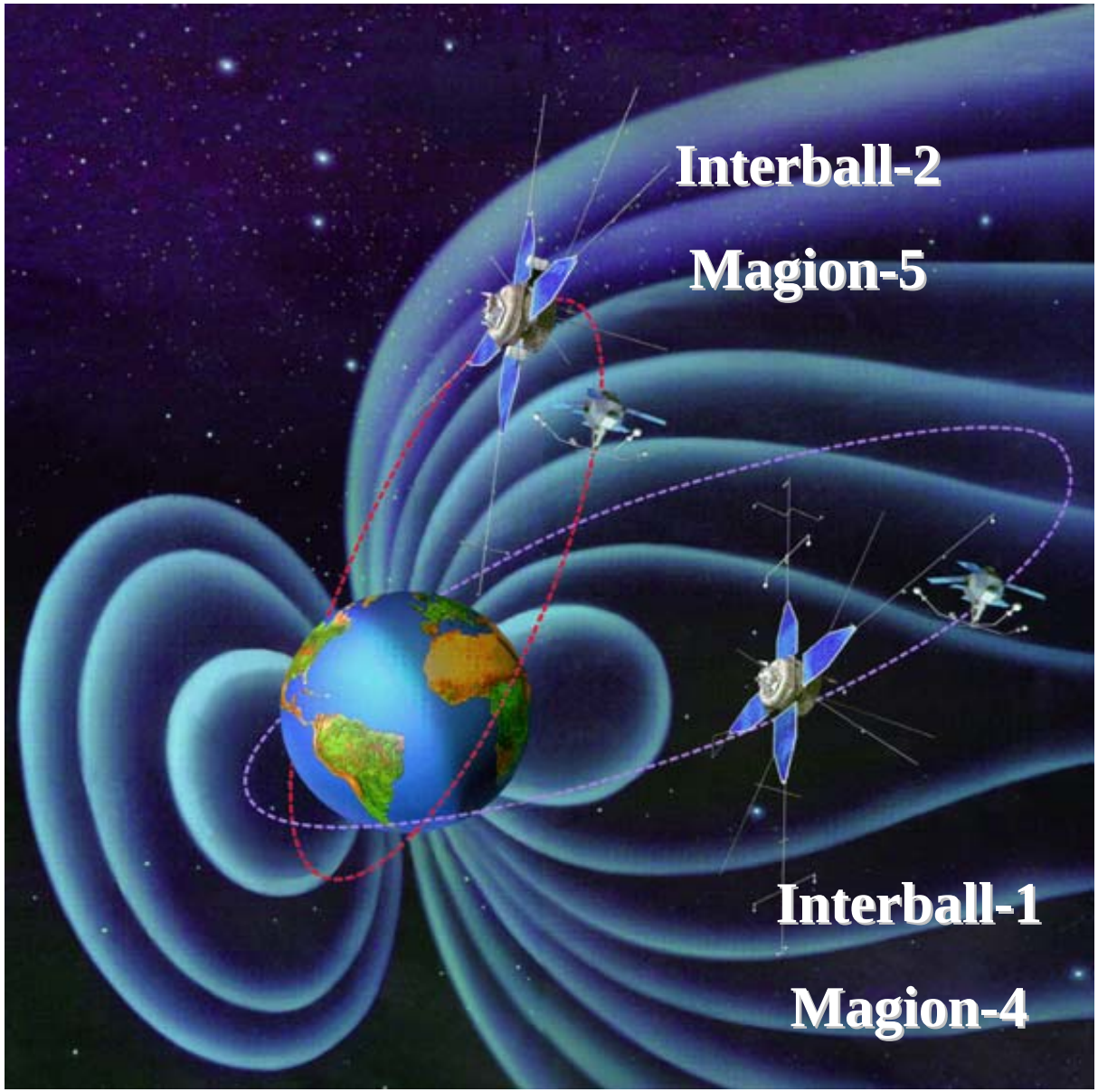
Spacecraft weight, kg	- 1900
Scientific payload weight, kg	- 540
Orbit:	
• type	- circular
• height, km	- 500
• inclination, deg	- 82.5



Moscow Engineering Physics Institute (State University) MEPhI

Participants: India, Poland

INTERBALL MISSION www.iki.rssi.ru/interball/



INTERBALL-1

Launch – 08.1995 г о д

- **Perigee - 785 к м**
- **Apogee - 200 000 к м**
- **Period - 92 ч**
- **Inclination– 62,8**

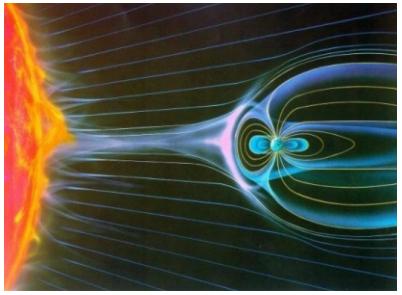
INTERBALL-2-

Reentry 16.10. 2000 г .

Launch – 08.1996 г о д

- **Perigee - 770 к м**
- **Apogee - 20 000 к м**
- **Period - 6 ч**
- **Inclination– 62,8**

Lost 02. 99



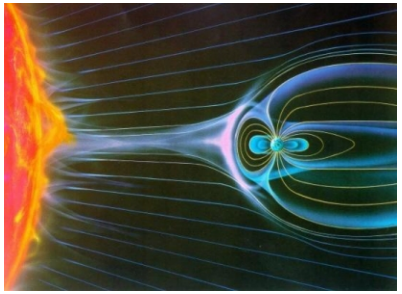
INTERBALL MISSION

www.iki.rssi.ru/interball/

- solar wind and interplanetary magnetic field

The INTERBALL project involves the efforts of a large international community of Russia together with Austria, Bulgaria, Canada, Czechia, ESA, Finland, France, Germany, Hungary, Italy, Kirgizia, Poland, Romania, Slovakia, Sweden, United Kingdom and Ukraine.

Besides that a close cooperation within the project with the ground-based geophysical observations community will allow a timely information on the current solar and geophysical conditions which are indispensable to put the satellite data in the global solar-terrestrial perspective.



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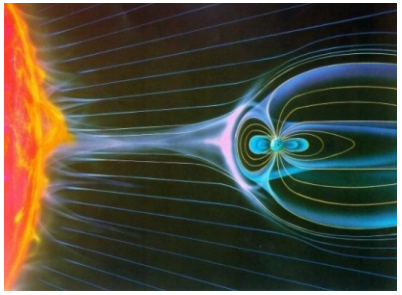
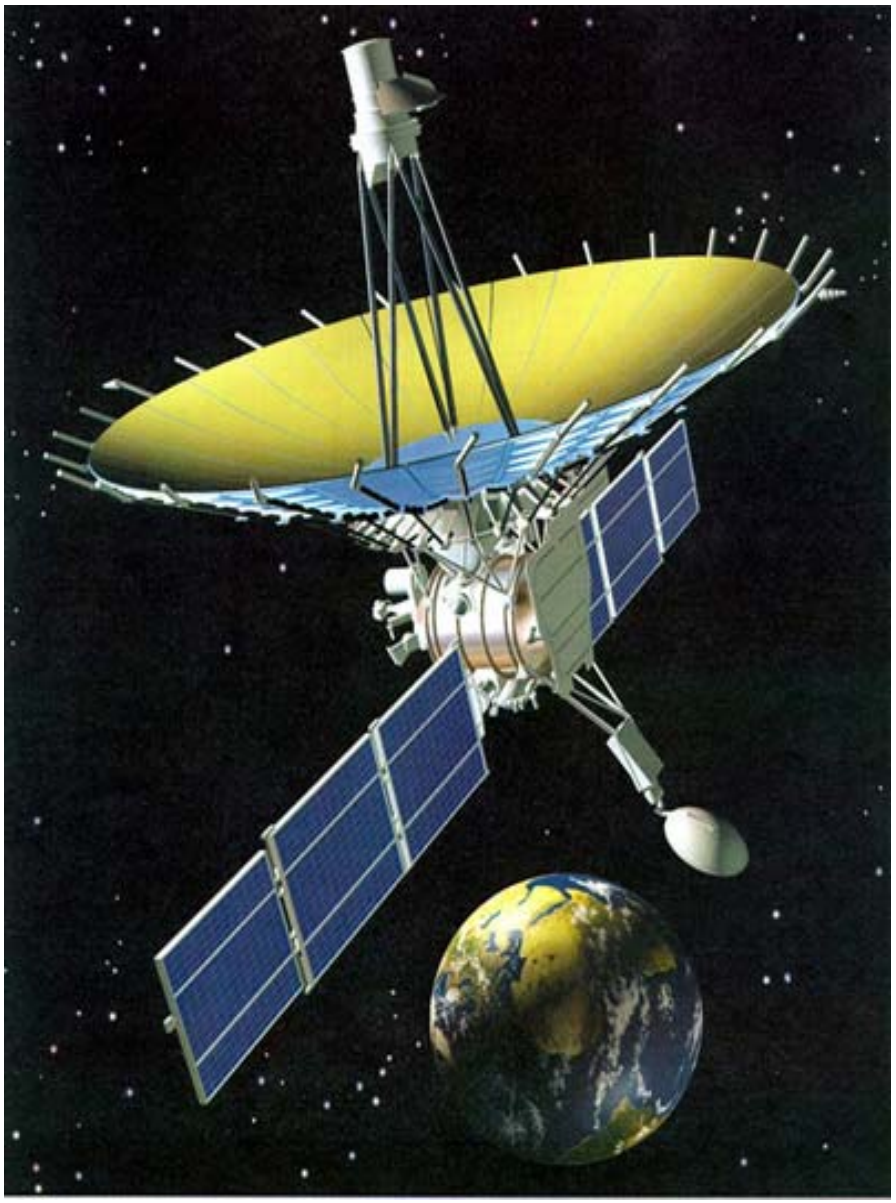
FUTURE

1. *SPECTR-R (Radio-Astron) – 2010.*
2. *Phobos-Ground (Soil) – 2011.*
3. *RESONANCE - 2012.*



THE PROJECT "SPECTR-R" (Mission "Radio-Astron")

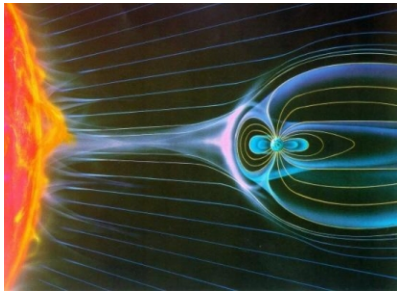


SPECTR-R

is an International space VLBI project of Russian Space Agency.

*A 10-meter radio telescope will be launched in **2010** to an orbit with*

apogee 350 000 km,
perigee 5 000 km
inclination 54°.



Solar-terrestrial payload on SPECTR-R

- solar wind and interplanetary magnetic field

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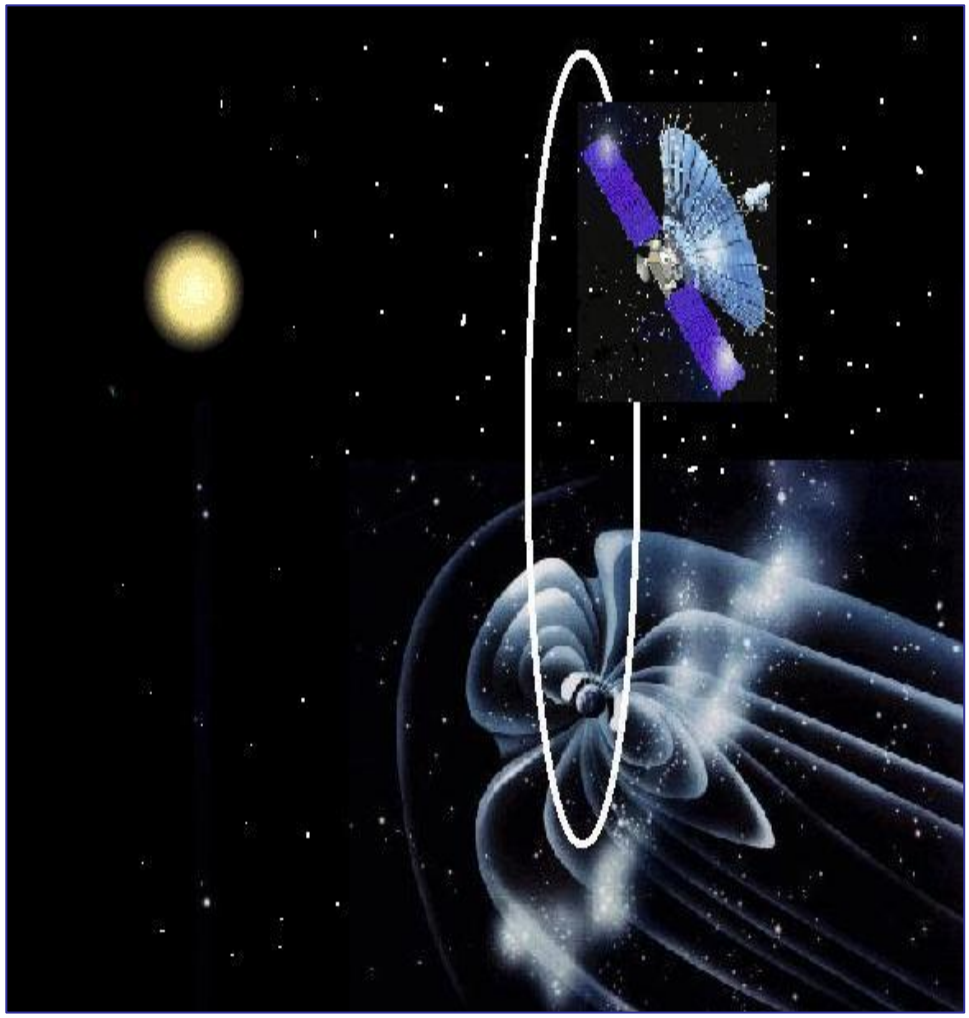


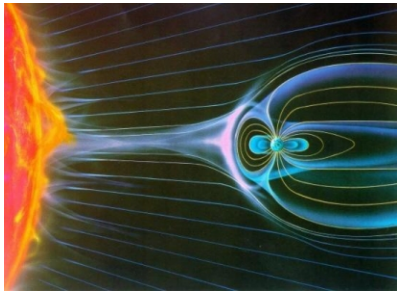
On its 9-day orbit, the spacecraft will spend 90% of time in near-Earth interplanetary medium and thus it is a convenient platform for a solar wind experiment.

PLASMA-F

is solar-terrestiral payload of opportunity onboard SPECTR-R.

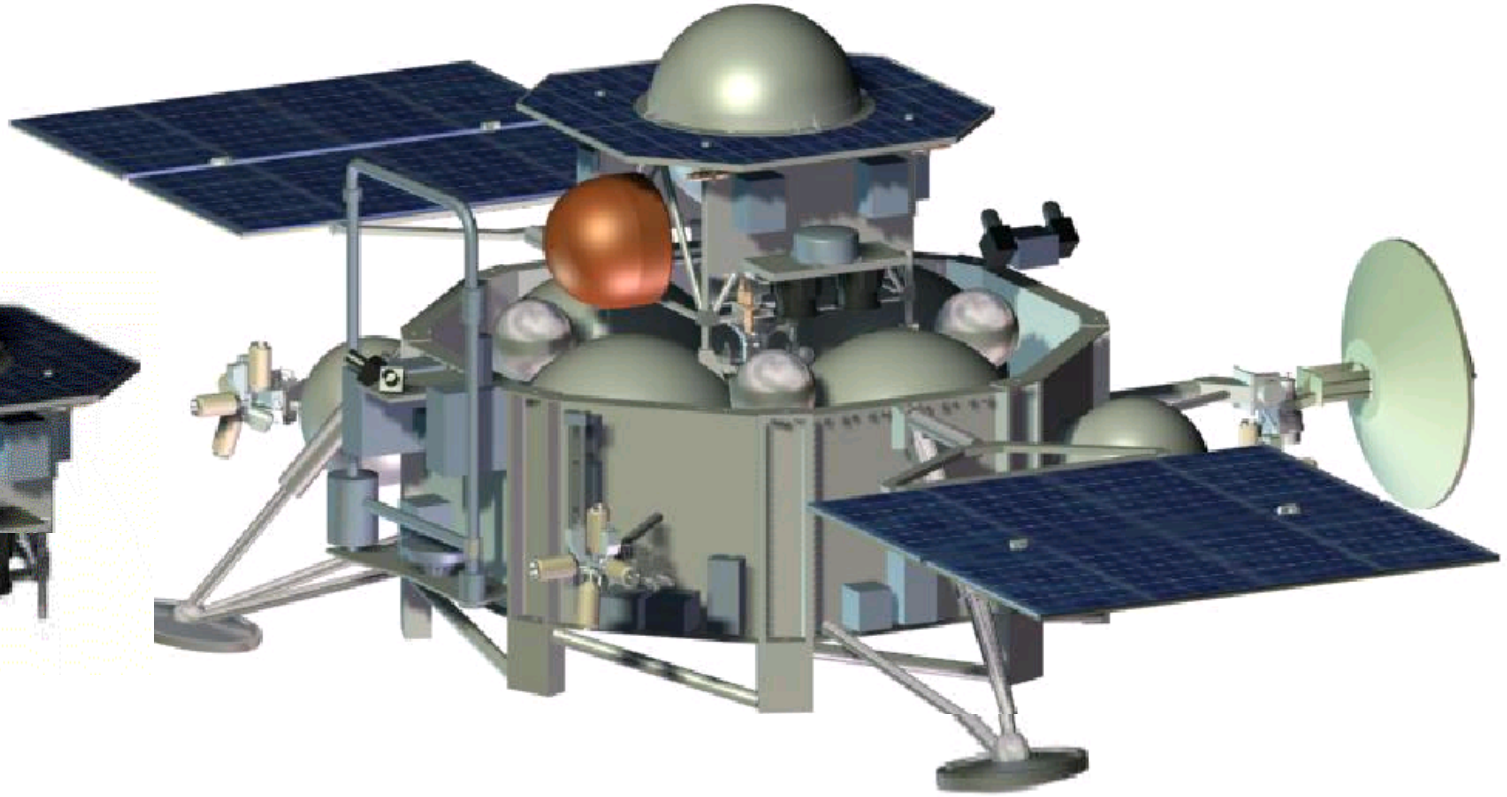
PLASMA-F with participation of China, Czechia, Greece, Slovakia, Ukraine.

Phobos-Ground (Phobos-Soil) - 2012

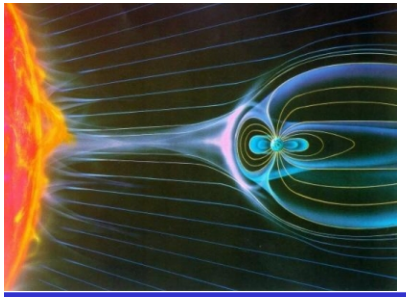


400 kg

12 kg, **0,1 kg**



–Phobos investigation (regolith, origin and evolution of the Martian moons)
–Martian environment conditions (dust, plasma, radiation)
–Monitoring of the Martian atmosphere and surface global dynamics



Phobos-Grunt: Plasma-Magnetic System

France, Germany, Hungary, Ukraine

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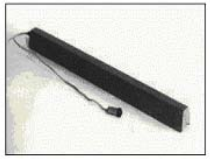
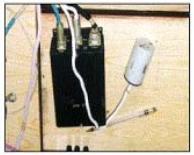
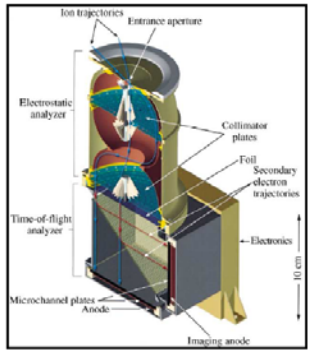


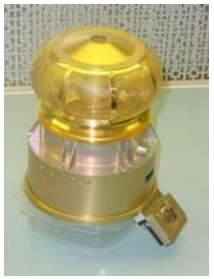


Magnetic sensors: search-coil and fluxgate

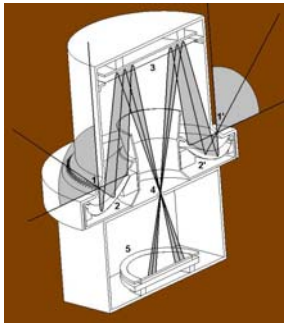
Digital Processing unit



Pick-up ion sensor 10eV – 50KeV



Electron sensor 1eV –5KeV

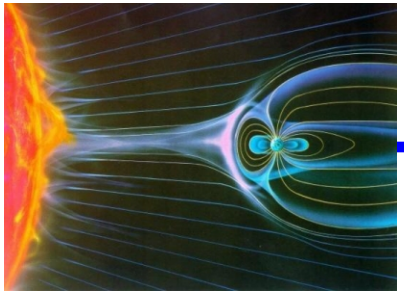


Planetary ion sensor 10eV – 15KeV

Spacecraft

Total: weight - 3 kg,; power - 3.3 W.

- solar wind and interplanetary magnetic field



RESONANCE

Mission Implementation:

Expected launch date: 2012

Nominal mission duration: 2 years

Orbit: Elliptic high-inclination

apogee 28000 km, perigee 500 km

Heritage Missions: Interball-2

Science Objectives:

Investigation of wave-particle interactions and plasma dynamics in the inner magnetosphere

Magnetospheric cyclotron maser
Auroral region small-scale processes

Space weather-related: ring current and outer radiation belt, plasmasphere

- **Bulgaria – SRI BAS**
- **Czechia – IAP CAS**
- **Finland – Oulu univ.**
- **France – LPCE/CNRS, CESR CNRS**
- **Germany – IMP Lindau**
- **Greece – Thrace Univ.**
- **Poland CBK PAN**
- **Slovakia – IEP SAS**
- **Ukraine – LSC SRI NANU/NCAU, IA NANU**
- **USA – Mariland Univ.**

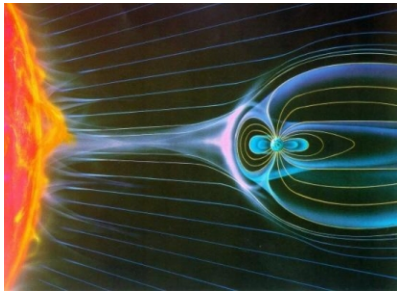
Instruments:
DC and AC vector magnetic fields
Magnetic and electric spectrum analysis

Fast electron spectrometer: 1-50 keV

Ion and electron spectrometers for hot plasma

Plasmaspheric plasma analyzer

Energetic particle spectrometer
Relativistic electron spectrometer



RESONANCE - 2012

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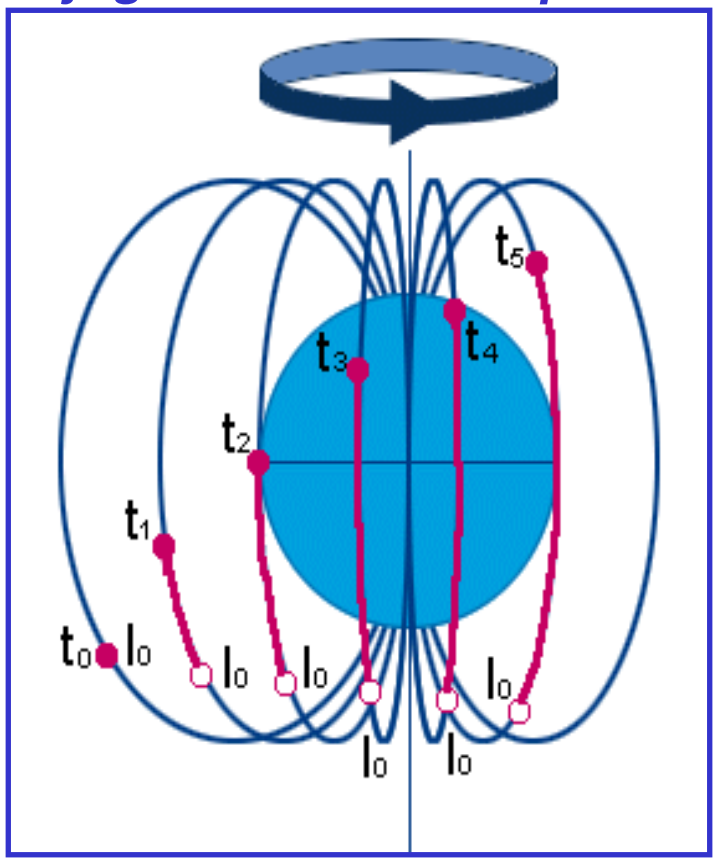
Magnetosynhronous orbit

RESONANCE satellite motion along the selected magnetic flux tube mapped of the heating station. Footprint of the selected tube will be conjugate to the ionosphere above the HF heating facility HAARP.

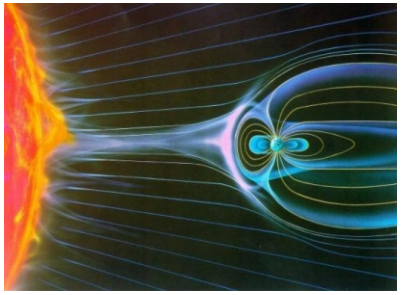


Two pairs of satellites for multiscale studies in the inner magnetosphere

Satellite spends

more then 3 hours

in the same flux tube (L=5.5±0.15)



RESONANCE

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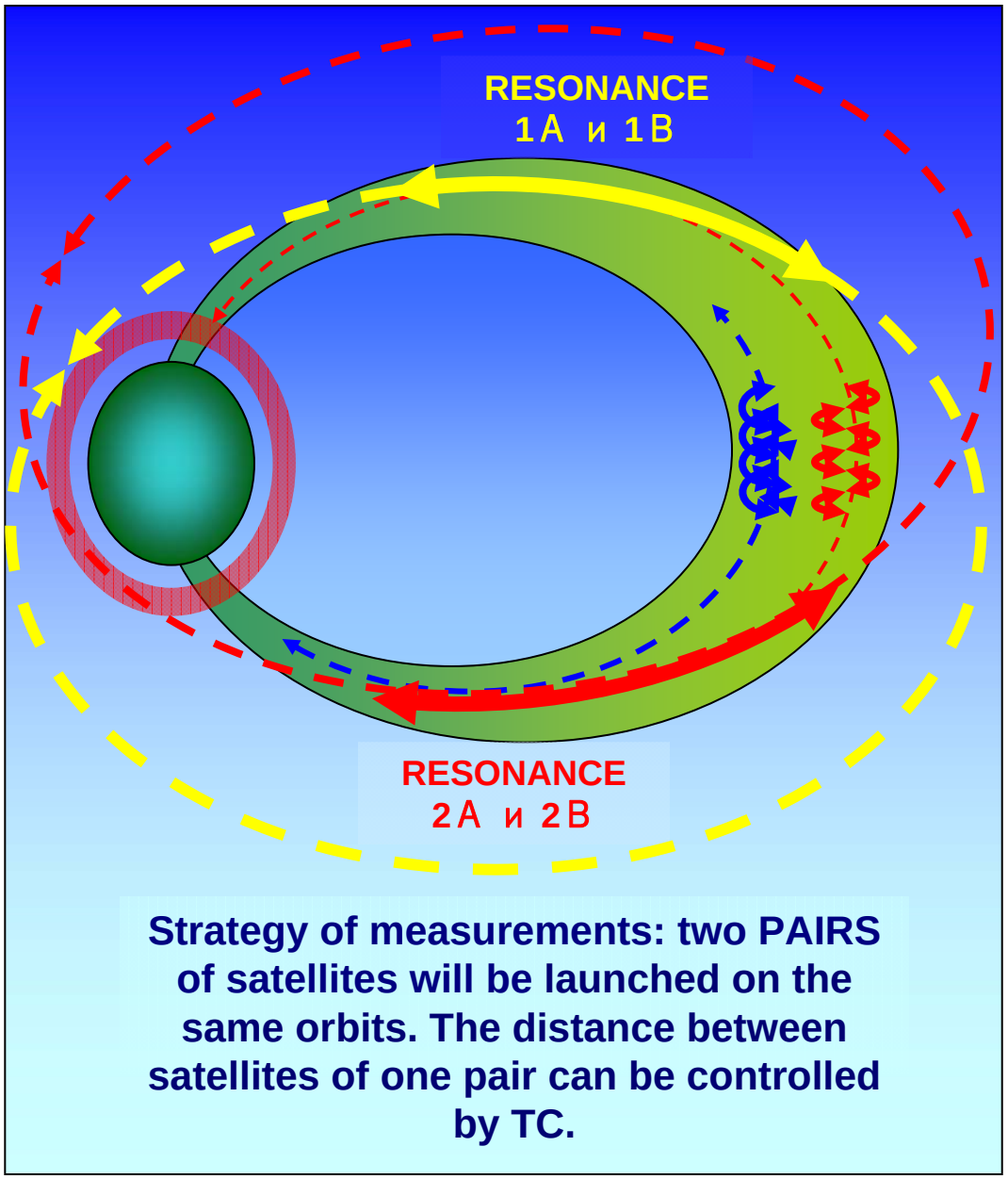
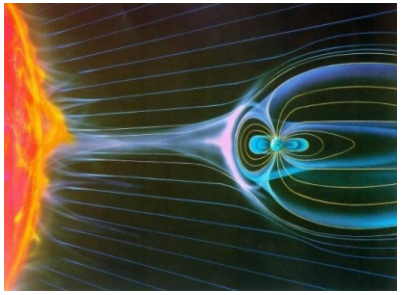
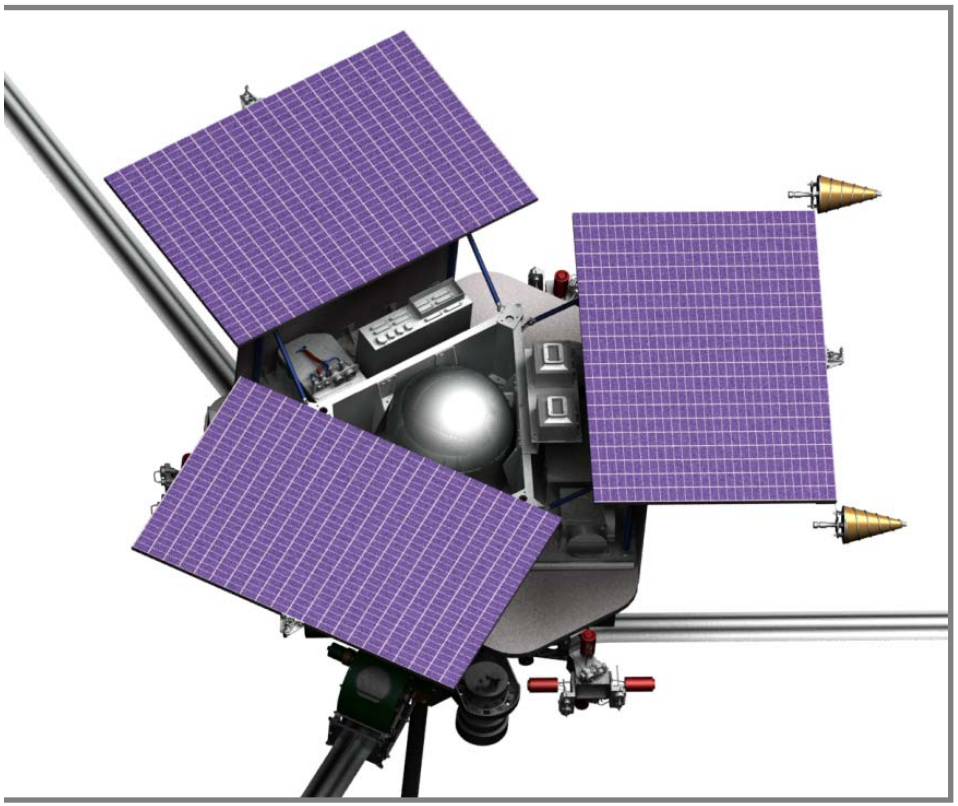


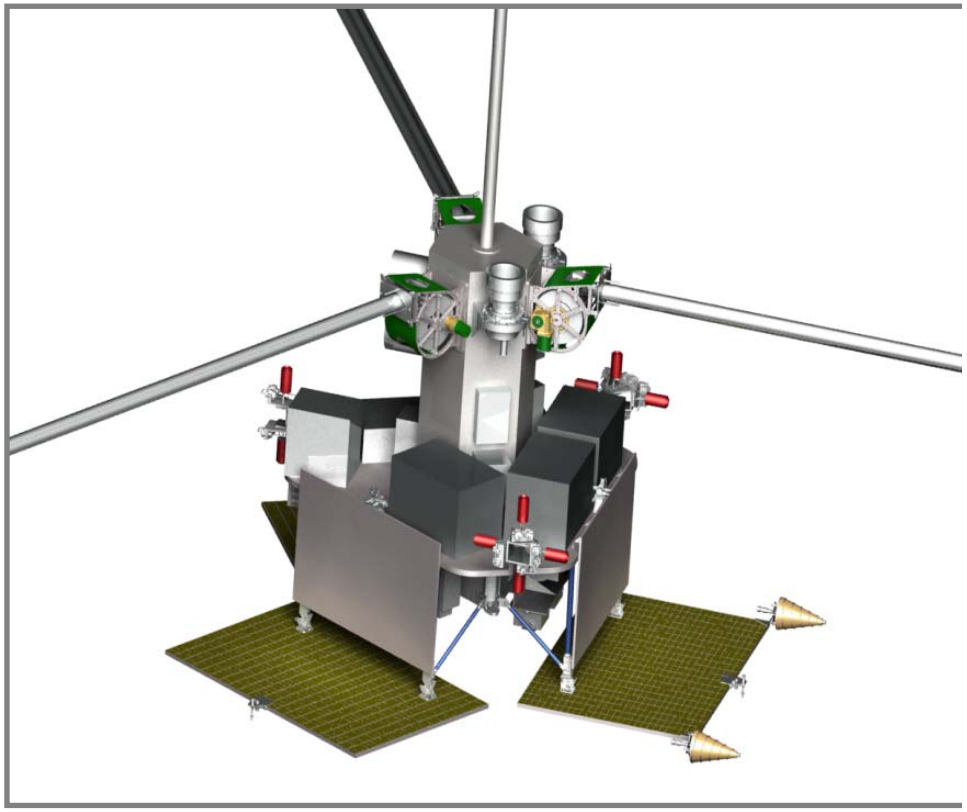
Strategy of measurements: two PAIRS of satellites will be launched on the same orbits. The distance between satellites of one pair can be controlled by TC.



KARAT – RESONANCE satellites

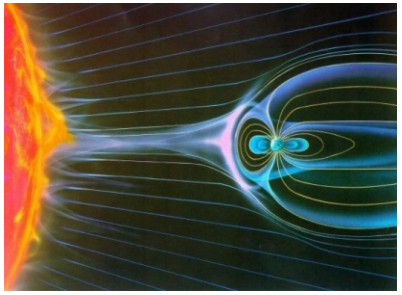
ИКИ





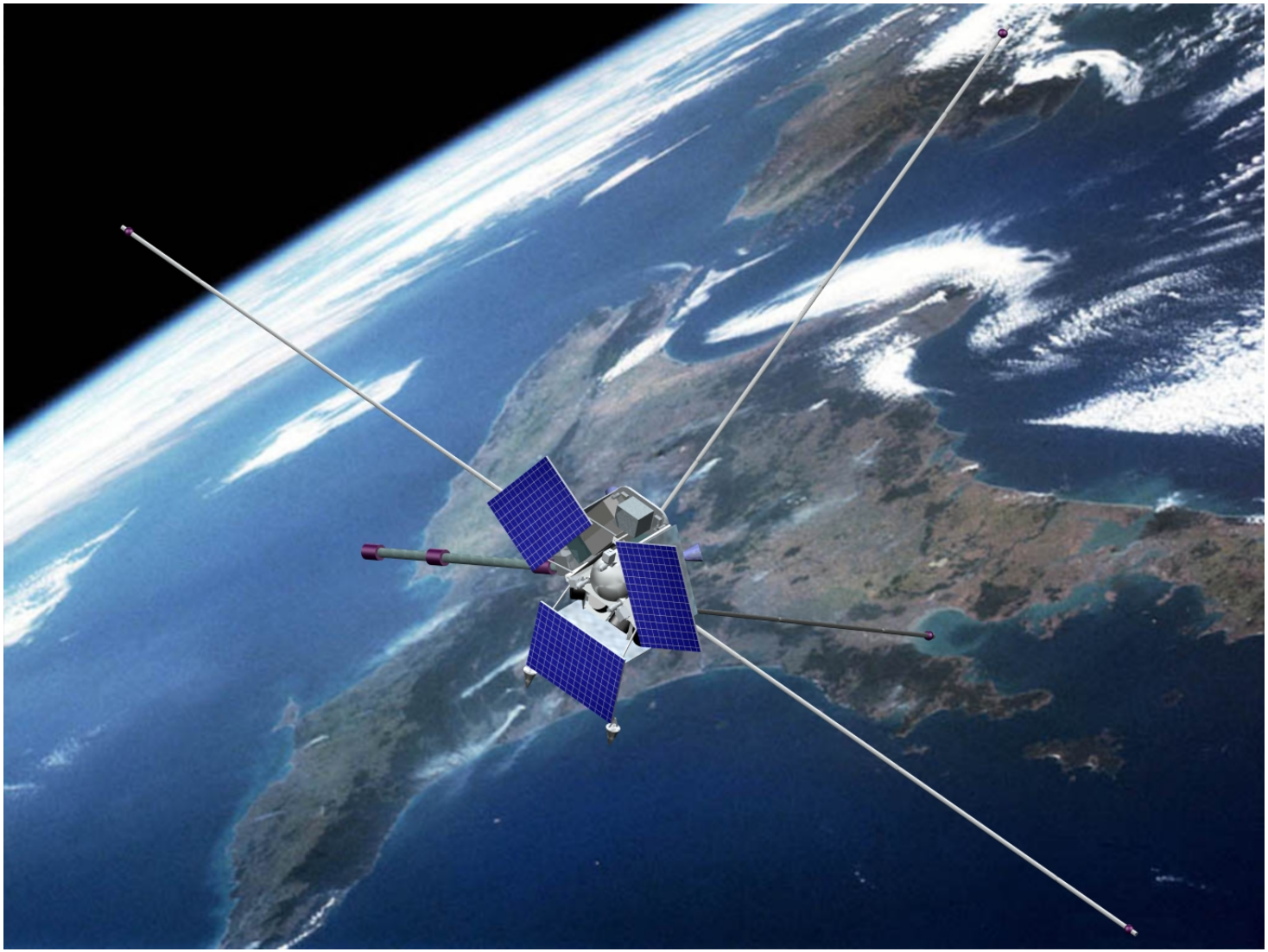
Flight position of satellite

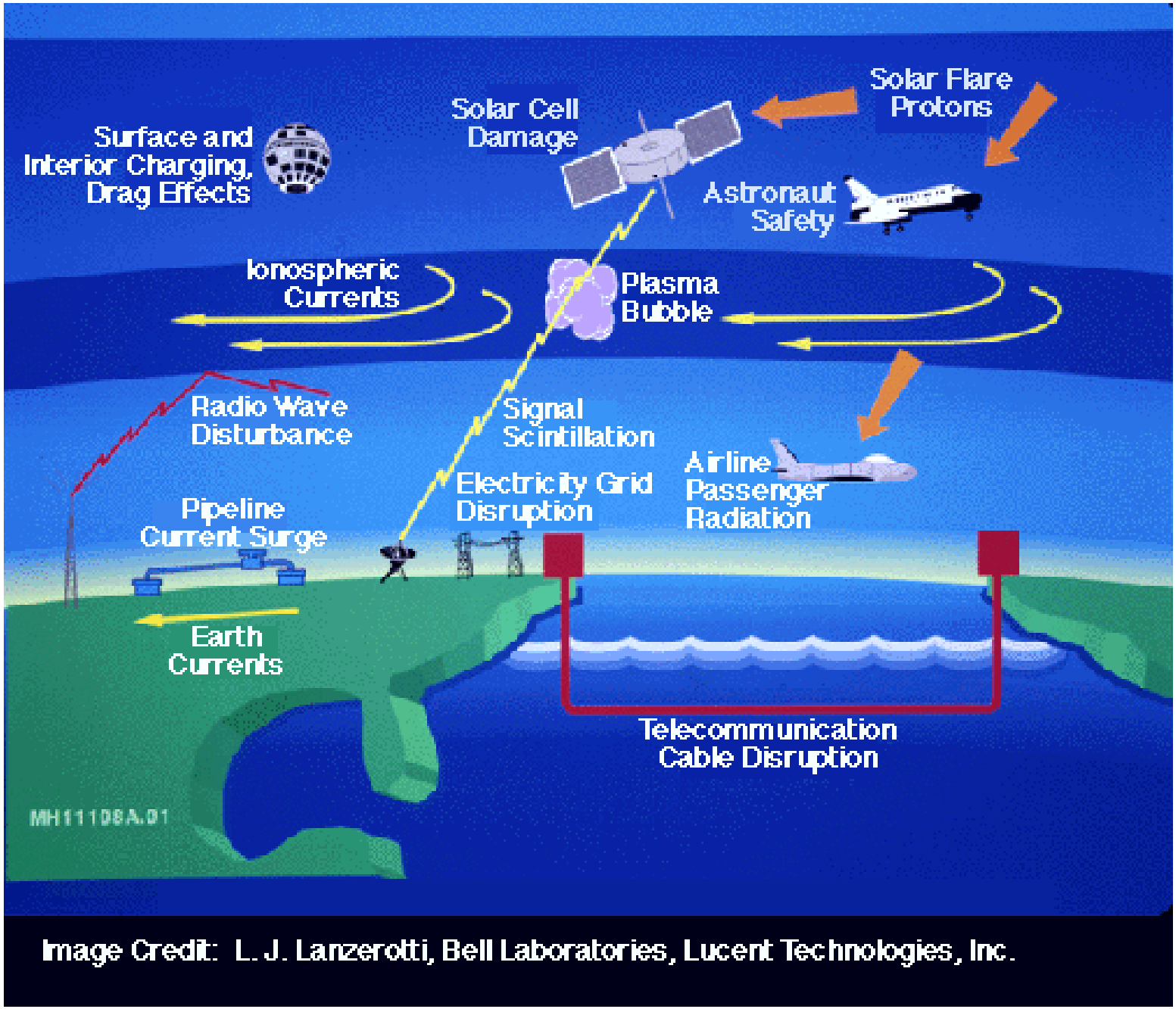
(from sun direction) **(anti-sun direction)**

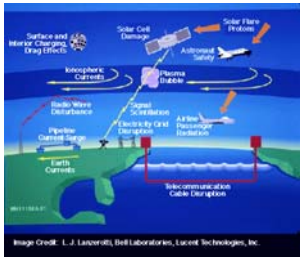


KARAT – RESONANCE satellites

ИКИ




Surface and
Interior Charging,
Drag Effects
Solar Cell
Damage
Solar Flare
Protons
Astronaut
Safety
Ionospheric
Currents
Plasma
Bubble
Radio Wave
Disturbance
Signal
Scintillation
Airline
Passenger
Radiation
Electricity Grid
Disruption
Pipeline
Current Surge
Earth
Currents
Telecommunication
Cable Disruption
MH11108A.01
Image Credit: L. J. Lanzerotti, Bell Laboratories, Lucent Technologies, Inc.



ИКИ

FUTURE

4. *Experiment « Obstanovka 1-st stage » on the Russian Segment of the ISS - 2011.*
5. *Micro-satellite – 2011.*
6. *RELEC – 2012.*

www.iki.rssi.ru/obstanovka

Experiment « Obstanovka 1-st stage » on the Russian Segment of the ISS.

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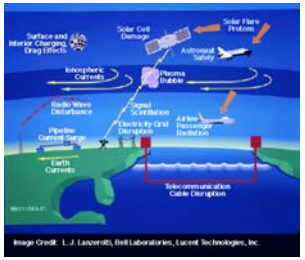
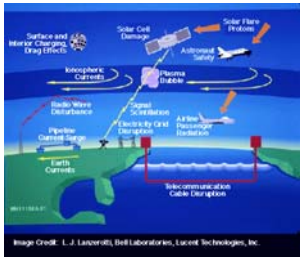


www.iki.rssi.ru/obstanovka

ИКИ

PWC composition

Units	Responsible Institute
Combined wave sensor – CWS-1, CWS-2	LC ISR, **Ukraine**
Flux gate magnetometer (analog) – DFM-1	IKI RAN , **Russia**
Flux gate magnetometer (digital) – DFM-2	LC ISR, **Ukraine**
Langmuir probe - LP-1, LP-2	STIL BAN, **Bulgaria**
Spacecraft potential monitor - DP-1, DP-2	IKI BAN, **Bulgaria**
Correlating Electron Spectrograph (10eV – 10KeV) CORES	Sussex University, **UK**
Radio Frequency Analyzer – RFA	SRC PAN, **Poland**
	SISP, **Sweden**;
Signal Analyzer and Sampler – SAS3	SRG, BLE, **Hungary**
Data Acquisition and Control Unit - DACU-1, DACU-1	KFKI RMKI, **Hungary**;
Block of Storage of Telemetry Information – BSTM	KFKI RMKI, **Hungary**;
Grounding support equipment – GSE	KFKI RMKI, **Hungary**;
Booms	RSC “Energia”, **Russia**
PWC integration	IKI RAN , **Russia**

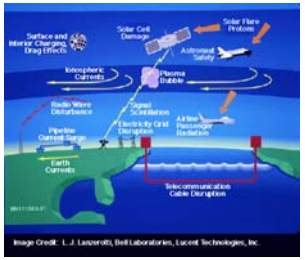


Coordinated Ground Observations Program

The development of the Program accompanying the “Obstanovka” experiment started in 2005

Regional planning meeting for the Balkan and Black Sea region (http://www.stil.bas.bg/IHY/) recommended to organize the coordinated ground observations

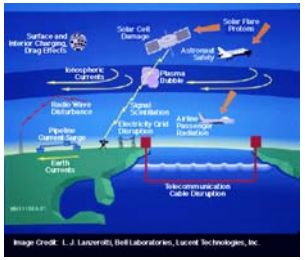
Bulgaria, Armenia, Azerbaijan, Croatia, Georgia, Greece, Poland, Romania, Russia, Serbia and Montenegro and Ukraine



Micro-satellite “Kolibri-2000”

http://www.energia.ru/english/energia/sci-education/microsat/microsat-02.html

The first Russian- Australian scientific- educational micro-satellite "Kolibri -2000" (total mass of 20,5 kg), on 20 March, 2002, has been injected into orbit of International Space Station (ISS) by separation from the transport vehicle “Progress”.

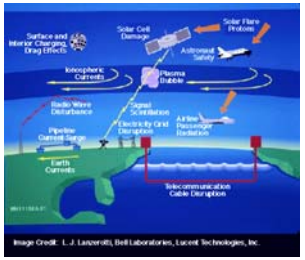


Micro-satellite “Kolibri-2000”

ИКИ

http://www.energia.ru/english/energia/sci-education/microsat/microsat-02.html

“Kolibri-2000”
Total mass – 12,5 kg



Micro-satellite “Chibis”

http://chibis.cosmos.ru

ИКИ

In IKI RAN is finished the phase "A" –

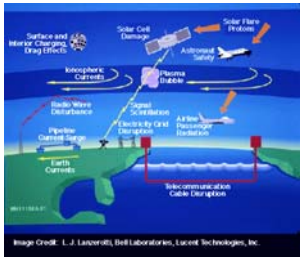
is developed the model composition of

the complex of scientific instruments, support systems,

and construction of micro-satellite "Chibis".

Micro-satellite "Chibis" is executed with the use of an

experience of micro-satellite "Kolibri-2000“



Micro-satellite “Chibis”

http://chibis.cosmos.ru

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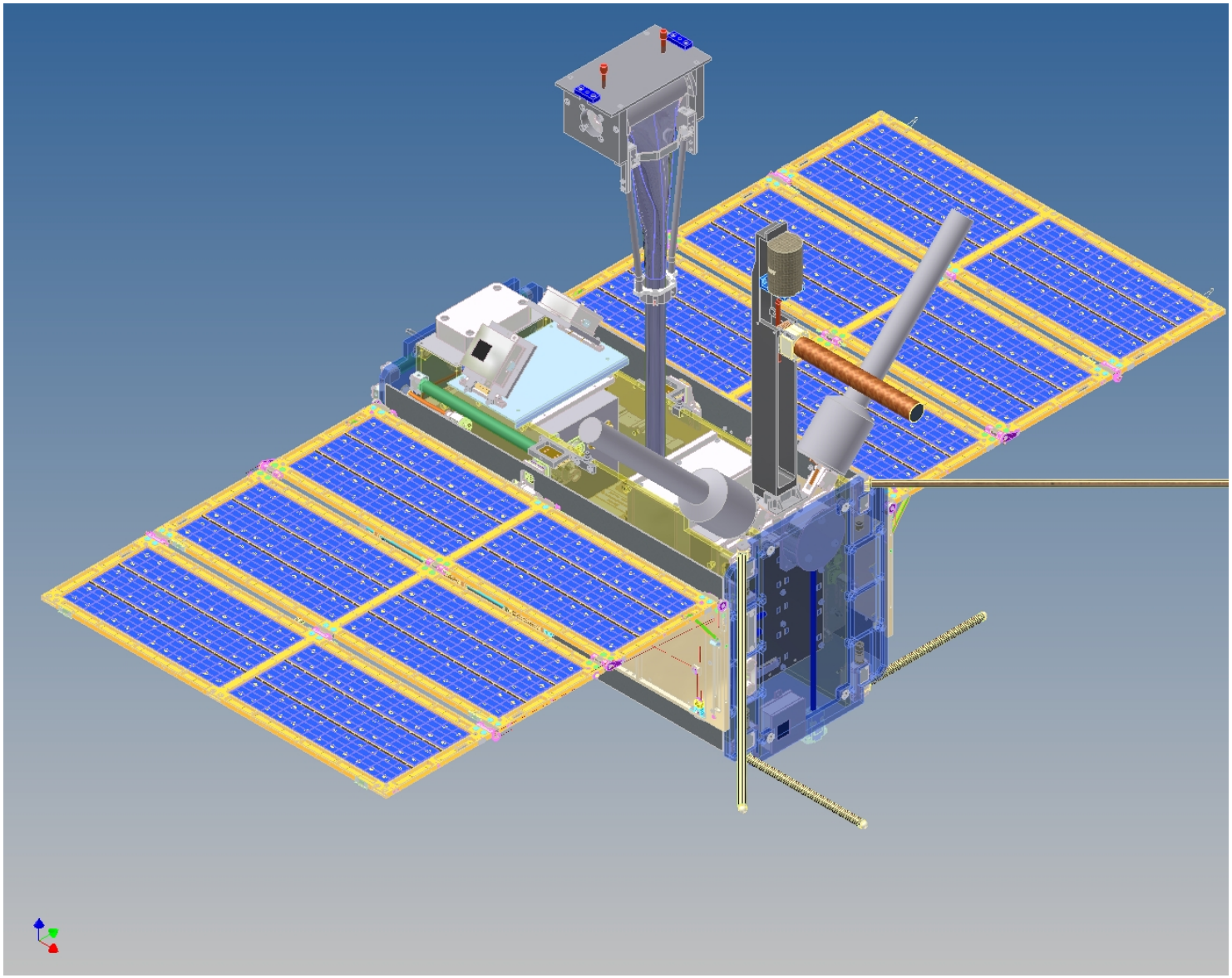
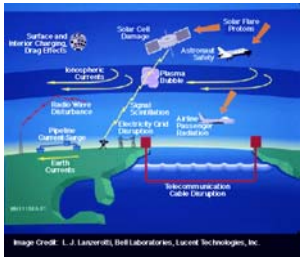
Total mass – 40 kg





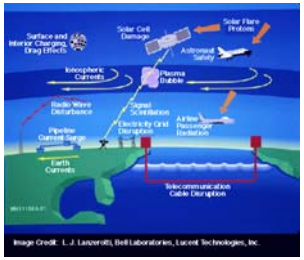
Micro-satellite “Chibis”

ИКИ

http://chibis.cosmos.ru

Main technical characteristics of the micro-satellite "Chibis".

Mass	**- 40 kg.**
Scientific instruments	**- 12.5 kg.**
Service system	**- 18.2 kg.**
Construction and temperature control system	**- 9.3 kg.**
Orbit	**- circular ~ of 480 km.**
Orientation systems:	
- types: the electromechanical (electroflywheels) magnetodynamic (electromagnets) gravitational (boom);	
- accuracy of the determination of orientation from the sensors (starry, solar) and systems GPS - GLONASS	**- to 2- angl. deg.**
- accuracy of guidance	**+/- 3 - 15 angl. deg.**
Data-transmission system:	
- S/C-Earth	**- 1 Mbit/s**
- the capacity of onboard storage	**- 50 Gbytes**
- the volume of the adopted from the board information	**- ~ 50 Mbayt/day**
The radio frequency of command and service links	**145, 435 MHz.**
The radio frequency of telemetrie link	**2200 MHz.**
The system of onboard power supply	**50 W:**



Micro-satellite “Chibis”

http://chibis.cosmos.ru

ИКИ

Scientific instruments - 12.5 kg.

RGD - Roentgen - gamma detector (range of X-ray and gamma emissions - 50-500 keV);

DUF - Ultraviolet detector (range of ultraviolet radiations - 300-450 nm);

RFA - Radio-frequency analyzer (20-50 MHz);

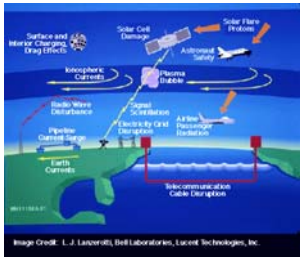
DPC - Camera of optical range (spatial resolution 300 m)

MWC – Magnetc - wave complex (0.1-40 kHz).

Complex of scientific instruments (CSI), existed on micro-satellite CHIBIS-M oriented on the study of high altitude lightning.

CSI also oriented on the study of electromagnetic parameters of the space weather in ionosphere.

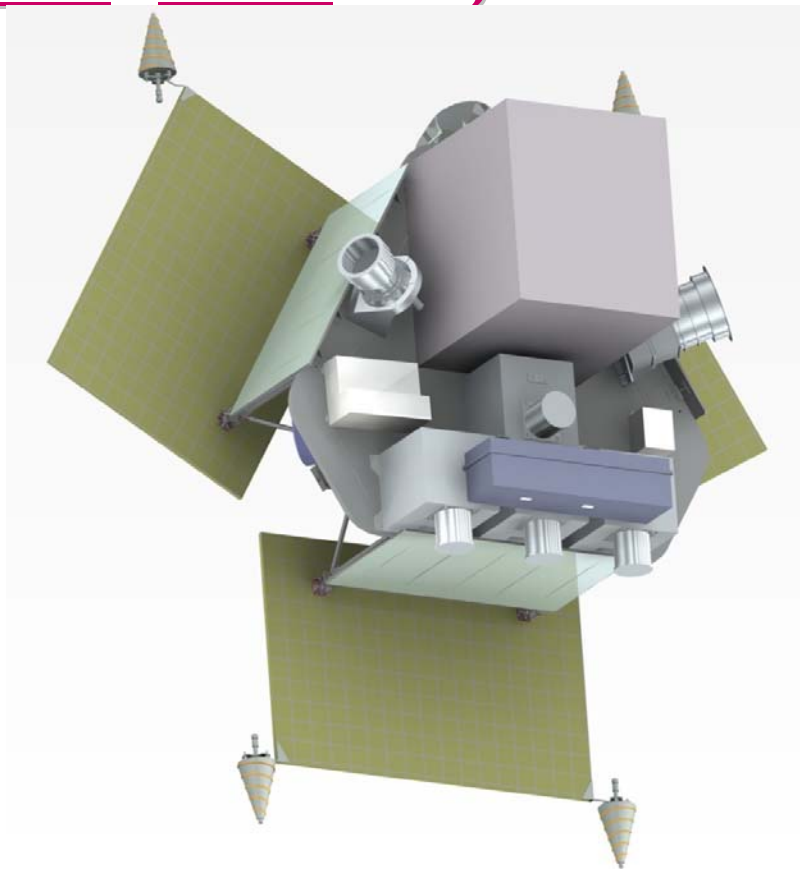
Necessary to note that micro-satellite delivery on the orbit was realized by using infrastructure of the Russian segment of the International Space Station.



RELEC project (*Relativistic* ELEC*trons*)

Scientific objective of the project:

- Investigation of the impact of the physical mechanisms of solar, magnetosphere, atmosphere nature on atmosphere of the Earth.
- Study of the solar cosmic rays physical mechanisms, which are developed in active processes on the Sun and in heliosphere.



Total mass on orbit	– 110 kg.
Orientation	- 3 axis
Life time on orbit	- > 3 years
Scientific payload	
Mass	- 27 kg.
Power	- 36 W.
Data flow	- 10-20 Mb/day.

Conclusion

Program Russian Academy of Science along the space weather is directed toward finalizing of the experimental methods of determining the current parameters of space weather in different regions of near-earth and interplanetary space.

The system of the prediction of space weather, directed toward the study of the following effects of space weather, can be worked out on the basis of these methods subsequently:

- *Action of cosmic radiation on the equipment of spacecraft and aircraft, radiation threat for the cosmonauts and the crews of high-altitude aircraft,*
- *Changes in the conditions of the radiowave propagation and interference in the communication systems and the navigation, created by the ionosphere and the magnetosphere.*
- *Change in the orbits of spacecraft because of heating of the upper atmosphere.*
- *Geo-induced (spurious) currents in the conducting units and the systems: tubes-lines, cables, the electric power lines and communications, railroads in the circumpolar latitudes.*
- *Modifications of chemical composition and properties of the Earth's atmosphere.*
- *Action on the biological subjects and the man.*

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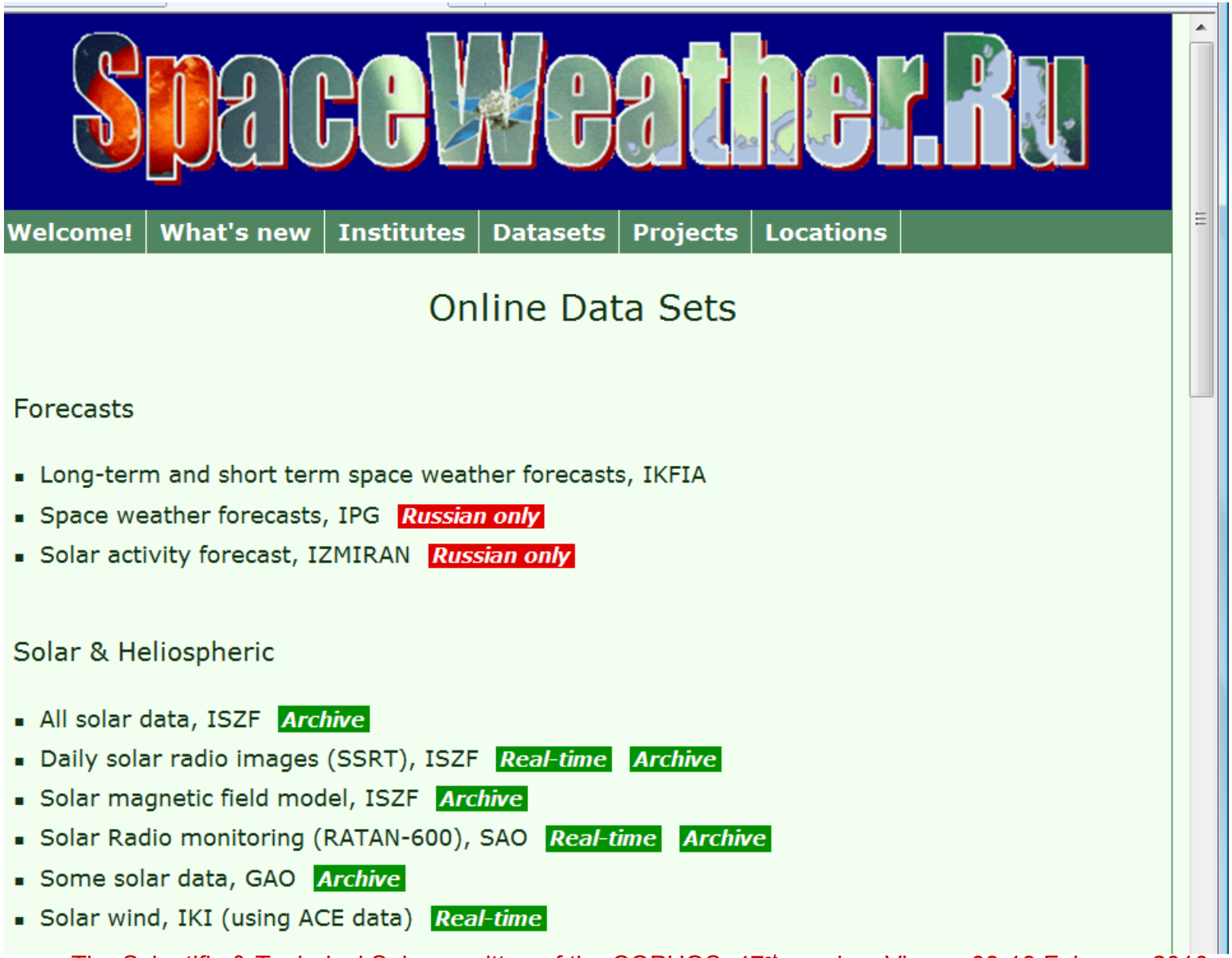
Obtained from the spacecraft experimental data will be introduced on Web-site of Russian space-weather program (SpaceWeather.ru).

Web-site with catalogue of Russian space-weather related Internet

Web-site with catalogue of Russian space-weather related Internet



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Thanks for the attention

Distinguished Chairman

and

Respected Delegates