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# The ADAHELI (ADvanced Astronomy for HELIophysics) solar mission

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**Abstract.** The ADAHELI (ADvanced Astronomy for HELIOphysics) small mission is an Italian project for the investigation of solar activity and dynamics proposed in the framework of ASI Italian Space Agency Small Missions Program call. It is devoted to the study of photospheric and chromospheric structure and dynamics.
The scientific payload consists of ISODY, a telescope with a focal plane suite operating in the visible and near infrared, and MIOS, a 90GHz radiometer. The telescope is equipped with a spectro-polarimetric imager, based on Fabry-Perot interferometers, a broad band imager, and an image stabilization system. The 90GHz radiometer is a full-disk instrument exploiting an antenna with an angular aperture of about $\pm 25 arcmin$. Proposals for optional instruments are under evaluation: DIMMI-2h, a double channel magneto-optical filter based full disk imager, EISR a dual channel spectrometer operating in the EUV, and NPA, an in-situ Neutral Particle Analyzer to detect ENA.
We shortly present the scientific objectives of the mission, the scientific payload packages and a possible mission orbit. Possible dates for the launch are 2012 and 2014, both during the declining phase of solar activity.

**Key words.** Sun: photosphere - Sun: chromosphere - Methods: space mission

## 1. Introduction

The Sun is the source of energy which has allowed life to develop on the Earth, and has been the main driving force for climate until the present era. The influence of the sun extends across the entire solar system, both by its electromagnetic radiation, which illuminates, heats and ionizes solar system matter, and by the hot magnetized plasma expanding out of its outer atmosphere, the solar wind.

Understanding solar activity represents a necessary pre-requisite to the development of human space exploration, as well as for developing a true alert system for our sensitive services depending on Satellite technology.

ADAHELI will operate as a high spatial and spectral resolution imager of the solar visible surface (photosphere) and lower atmo-

*Send offprint requests to*: F. Berrilli sphere (chromosphere), in the Visible range and, for the first time from Space, in the Near Infrared. Designed Mission Profiles for ADAHELI intend to achieve continuous high-spectral and spatial resolution observations of the Sun for a routine duration of 4 hours, with a goal to be extended to 24 hours with the aim to investigate the coupling between the photosphere and the chromosphere, the interface layer with the hot corona.

The ADAHELI scientific payload integrates and complements, without overlap, the present major objectives of ESA, NASA and the International Living with a Star program, in particular SDO, PICARD, Solar Orbiter and Solar Probe missions.

The main Science instrument, ISODY, is a Gregorian telescope equipped with an innovative focal plane suite composed of a spectro-polarimetric imager, based upon two Fabry-Perot interferometers operating in the NIR regions, a broad band channel in the visible range, and a correlation tracker used as image stabilization system. ADAHELI also carries MIOS, a millimeter wavelengths radiometer operating at around 90 GHz for flare detection.

A very interesting and innovative capability may be added to the system through the association between ISODY and MIOS to work together a flare-watching service. This may be performed by letting ISODY to be reoriented in short time toward a flaring region, either through an autonomous guiding system, to be integrated into ISODY, or through a receiver (i.e., ORBCOM, Artemis, etc.) capable of routing external warnings to the System. This could be a significant augmentation of ADAHELI capabilities.

Optional instruments shall also be under evaluation. DIMMI-2h, a dual channel magneto-optical filter based full disk imager, EISR a double channel spectrometer operating in the EUV, and NPA, an in-situ Neutral Particle Analyzer.

## 2. Science with ADAHELI

Seven fields to highlight the specific benefits of ADAHELI scientific payload have been selected:

- Photospheric and chromospheric dynamics and structure
- Emergence and evolution of solar active regions and solar irradiance
- Chromospheric and corona heating and turbulence
- Solar flares in the millimeter wavelength region
- Helioseismology
- Basic physics: solar gravitational red-shift
- Origin of ENA between terrestrial magnetosphere and geocorona

The scientific topics from 1 to 4 will be investigated with ISODY and MIOS instruments, while augmented science objectives described in points 5-7 should be possible with DIMMI-2h and NPA experiments. EIRS science partially overlaps points 1-3.

The ISODY payload may provide the first high spectral resolution long period (4 hours with a goal of 24 hours) dataset of solar images in a couple of lines, the first one in the photosphere, the second one in the chromosphere. In particular, significant perspectives for chromospheric investigations can be provided by the study of (full) polarization state of the Ca II infrared triplet, around 854 nm, and He I multiplet at 1083 nm.

As a matter of fact, the chromosphere remains an ill-understood subject of solar physics. This interface layer between the photospheric plasma, dominated by the turbulent convective motions, and the tenuous corona, where most of the structure is determined by the magnetic field, still presents important observational and theoretical challenges to our comprehension of a stellar atmosphere. In particular, revealing the mechanisms sustaining the chromosphere's departure from radiative equilibrium will pave the way to understanding the presence of a hot corona, and the acceleration of the solar wind.

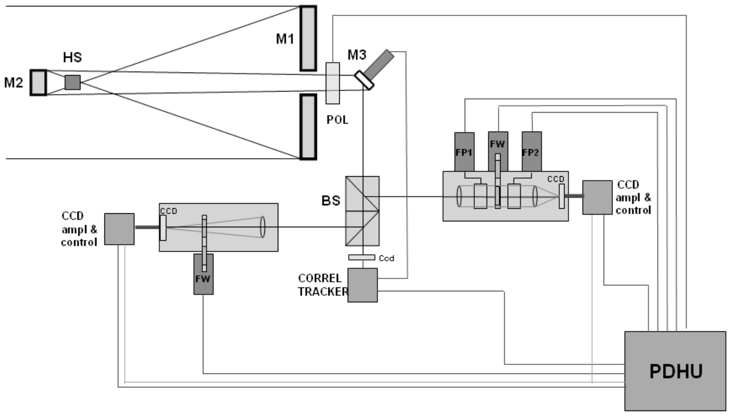


**Fig. 1.** Scheme of ISODY instrument. It contains the Gregorian solar telescope, the heat dump, the tip-tilt mirror (M3), the dichroic beam splitter for the BB and NB channels, and the correlation tracker for the image stabilization.

## 3. ADAHELI instruments

ADAHELI mission has two baseline instruments:

**ISODY** (Interferometer for Solar Dynamics) a 50 cm solar Gregorian telescope with a prolate ellipsoid primary mirror, with a heat dump and with a collimation lens equipped with a focal plane instrumental suite (Fig. 1). The focal plane instrument collection is composed of a narrow band spectral imager, based upon two Fabry-Perot interferometers operating in the NIR regions around 845 nm and 1083 nm, a broad band channel for high resolution imaging, and a correlation tracker. ISODY aims at obtaining high spatial, spectral, temporal, and photometric resolution images of the solar photosphere and chromosphere. A polarization analyzer is planned to be inserted into the beam, near the second focus, for magnetic field measurements.

**MIOS** (Millimeter-wave Instrument for the Observation of the Sun), a full solar disk 90GHz radiometer (Fig. 2). This instrument will be devoted to the measurement of the flux spectral density variations due to solar flares with long period of observation, high temporal resolution, and good sensitivity. Combining these three characteristics MIOS is expected to detect at least one order of magnitude more events than any other ground-based system.

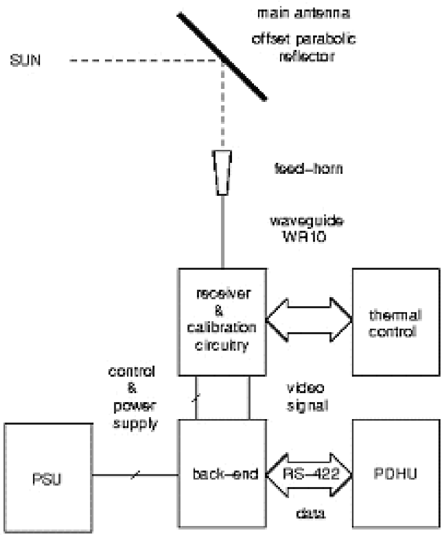


**Fig. 2.** Simplified block diagram of MIOS. The instrument is composed by three modules: the antenna module, the mmw radiometer module and back-end module.

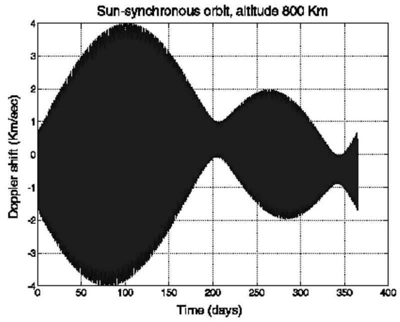


**Fig. 3.** The doppler shift behaviour during the time for a sun-synchronous orbit with 800 km of altitude.

Furthermore, three optional instruments are under consideration:

**DIMMI-2h** a solar full-disk imager based on two Magneto-Optical Filters (MOFs, first invented and developed in Italy by A. Cacciani and now being further developed at NASA/JPL) in the potassium 770 nm and sodium 589 nm lines. The instrument will provide simultaneous dopplergrams, intensity images and longitudinal magnetic flux images at two heights in the solar atmosphere.

**EIRS** is a compact two channel spectrometer operating in the 50-130 nm wavelength range. The main channel is an imaging channel (EIRS-I) aiming at providing spatially resolved high resolution spectra of the solar disk and off-limb corona imaged on a slit passing through the disk center and parallel to the Sun rotation axis. The second channel is a radiometric channel (EIRS-R) aiming at providing full disk spectral irradiance measurements.

**NPA** an instrument able to detect Energetic Neutral Atoms (ENA) radiating in two different directions: a) toward the Earth (originating from the plasma region in the Earth's inner magnetosphere) and b) upwards, (undergoing reflection from the Earth's atmosphere). The NPA consists of two spectrometers: NAOMI is a detector able to provide 2-D global imaging in the energy range 10-200 keV/amu), the central direction of the detector points anti-sunwards; ELENA covers the low energy spectrum ($\simeq 20\ eV - 5\ keV$) the useful observations will be toward the Earth (half orbit).

## 4. The orbit

The orbit selection has the objective to identify the orbit that is complying with the mission requirements. The main driver, in the searching of the suitable orbit, is the doppler shift. According to the requirements, the total amount of the doppler shift shall be less than 4 km/s with the goal to have 2 km/s for a duration as long as possible. The best candidate is a sun-synchronous orbit with 800 km of altitude. The doppler shift behavior during the orbit is shown in Fig.3.

## 5. Conclusions

ADAHELI mission provides a set of instruments which will enhance our understanding of the solar atmosphere and provide an important basis for the successful further development of research and space exploration in this field. Briefly, the most important are:

- ADAHELI is an ASI low-budget, high-performance solar Mission based on a proven Small-Satellite class platform (such as CGSs AGILE).
- ADAHELI is the first ASI project fully devoted to Heliophysics.
- ADAHELI will be the first mission to carry on-board a spectro polarimetric imaging instrument based on a double Fabry-Perot interferometer, exploiting a new technology for future space imagers.
- ADAHELIs instrument suite integrates and complements without overlap - the present major objectives of ESA, NASA, JAXA and the International Living with a Star program.

Moreover, the suite of instruments on-board the ADAHELI satellite provides the unique opportunity to create the first real-time detection and observation service of solar flares, through a trigger sent by the MIOS radiometer.

## References

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