5th SSEWG Meeting
17-19 January 2011

Report

Solar System Missions Division (SRE-SM)

1 Satellites in Orbit

1.1 SOHO

A spacecraft roll manoeuvre on 29 October 2009 marked the beginning of the SOHO "Bogart" mission in which SOHO will be aligned with ecliptic North/South rather than solar North/South.

JHelioviewer, a new visualization software that enables to explore all SOHO images from the past 15+ years as well as images from NASA's Solar Dynamics Observatory, was launched on 14 December in conjunction with the AGU fall meeting. JHelioviewer allows users to overlay series of images from the Sun, from different instruments, and compile animated sequences and image-process those in real-time. In addition, it allows cross-referencing of different aspects of the large data sets. This is particularly important as many events observed on the Sun are interconnected and occur over vastly different temporal and spatial scales. More at:
http://soho.esac.esa.int/hotshots/2010_12_14/
The release was widely covered by the media and countless blogs.

On 26 December 2010, SOHO discovered its 2000th comet. Drawing on help from citizen scientists around the world, SOHO has become the single greatest comet finder of all time. The 1999th and 2000th comets were both discovered on 26 December 2010 by Michal Kusiak, an astronomy student at Jagiellonian University in Krakow, Poland. Kusiak found his first SOHO comet in November 2007 and has since found more than 100. More details at:
http://soho.esac.esa.int/hotshots/2010_12_28/
The discovery was widely reported in the media.

Kretzschmar et al. (Nature Physics 6, 690, 2010) have analyzed 11 years of SOHO/VIRGO and GOES data to study the effects of flares on total solar irradiance. They have found that the total energy radiated by flares (L_{bol}) exceeds the energy radiated in soft X-rays (L_x) by two orders of magnitude: $L_x/L_{bol} \approx 10^{-2}$. The results have implications for our understanding of solar flares and the variability of the Sun.

Frazin et al. (Solar Phys. 265, 19, 2010) have presented the first quantitative three-dimensional tomographic reconstruction of the electron density in the Sun's extended corona from LASCO C2 total brightness (B) measurements. This was possible because new calibrations both for LASCO C2 polarized brightness (pB) as well as B have now been made for the entire mission. As the LASCO C2 B archive is vastly larger than the pB archive, this technique will allow to determine the 3D electron density throughout the 15+ years since the launch of SOHO.

Vourlidas et al. (ApJ 722, 1522, 2010) have presented a comprehensive analysis of Coronal Mass Ejection (CME) mass and energy properties over a full solar cycle. Their analysis suggests the existence of two event classes: "normal" CMEs reaching constant mass for $>10R_{\odot}$ and "pseudo" CMEs which disappear in the C3 field of view. They also have found a sudden reduction in the CME mass in mid-2003, which may be related to a change in the electron content of the large-scale corona at that time, and they have noticed the presence of a 6-month periodicity in the ejected mass from 2003 onward.

Searches for exoplanets with radial velocity techniques are increasingly sensitive to stellar activity. Meunier et al. (A&A 519, A66, 2010) have combined simulations with Doppler and magnetic field measurements by MDI to study the impact of active regions on the radial velocity of the Sun. They have obtained an integrated radial velocity with amplitude over the solar cycle of about 8 m s^{-1}, which agrees with the result of their simulation within 30%. They conclude that the impact of the convective blueshift attenuation in magnetic regions will be critical to detect Earth-mass planets in the habitable zone around solar-like stars.

Using MDI Doppler images, Duvall & Birch (ApJ 725, L47, 2010) have measured for the first time the vertical component of supergranular motions. They have found a 10 m s^{-1} upflow at cell center and a 5 m s^{-1} downflow at the cell boundaries, confirming previous estimates.

Gray et al. (Reviews of Geophysics 48, RG4001, 2010) have published a very comprehensive review on "Solar Influences on Climate".

1.2 Cluster/Double Star

Fuselier et al. (JGR 115, A10207, 2010) have revealed a difference in magnetic reconnection rate linked to the level of magnetic shear. They have shown that strictly anti-parallel magnetic fields (shear = 180˚) result in a higher reconnection rate than that determined for component reconnection (when the shear is < 180˚). This result agrees with theory but shows a much greater difference than predicted. This difference remains unexplained.

Zhang et al. (JGR 115, A10237, 2010) have examined Cluster in-situ measurements of variable dayside reconnection rates forming ropes of magnetic flux and the conjugate ground based Chinese all-sky camera images from the Yellow River station on Svalbard, which show poleward moving auroral forms (the auroral signature of such flux ropes) and reconnection related erosion of the dayside magnetosphere. This paper demonstrates the continuing collaboration between China and Europe developed through the Cluster/Double Star program.

Fear et al. (JGR 115, A11217, 2010) have examined the asymmetry of Flux Transfer Events (FTEs), formed by the magnetic reconnection at the dayside magnetosphere. Several conceptual models have been proposed for the formation of FTEs including multiple and single reconnection lines. The paper compares FTE observations by Cluster at both high and low latitudes (due to the evolution of the orbit) to simulations and shows that the observations are more consistent with simulations with multiple x-lines. The asymmetry of the observed FTE structure is also shown to increase with distance from the subsolar region, consistent with a compression of the magnetic field ahead of the FTE structure and a rarefaction behind it. These observational results are proposed as a test for the validity of future modelling efforts.

Echim et al. (PSS, in press, ISSN 0032-0633, 2011) have used a combination of VEX and Cluster data to examine the nature of solar wind interaction with magnetised and un-magnetised planets. The paper discusses the observations and modelling of the magnetic boundary at Earth and Venus planets and the interface between the outer planetary plasma layers and the shocked solar wind. Mass and momentum transfer at Venus seems to be stronger than at Earth (see also section on VEX).

The Cluster Active Archive (CAA) development continues steadily. The number of new users on the CAA is steadily increasing with a total of 1131 and the total monthly download was 0.8 Terabytes in December 2010.

1.3 Cassini-Huygens

Since normal operations were resumed (24 November 2010, following Cassini "safing" on 3 November 2010), two low-altitudes flybys of Enceladus were performed (30 Nov. at 47.9 km altitude and 21 Dec. at 47.8 km altitudes). The first flyby was optimized for gravity science, while the second one was optimized for remote sensing of the plumes near the south pole and fields-and-particle measurements near the north pole.

12 Cassini Scientists have been formally added by NASA as European Co-Investigators to the Cassini PI-led teams. Two additional new European Co-I's for MAG are expected to be announced shortly.

A press briefing called "Ice Volcanoes and Hot Plasma Explosions: Highlights from NASA's Cassini Mission to Saturn," took place at the American Geophysical Union meeting in San Francisco on 16 December 2010. It covered two topics: the finding of a possible ice volcano, or cryovolcano, on Saturn's moon Titan and an analysis of hot plasma "explosions" around Saturn that are linked to mysterious, periodic magnetic field and radio signals from the planet. They were accompanied by a press release
(http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20101214/) about the cryovolcano and a feature story about the plasma clouds
(http://saturn.jpl.nasa.gov/news/cassinifeatures/feature20101214/).
Cassini science highlights and news are regularly posted on Cassini's JPL web page http://saturn.jpl.nasa.gov.

Two Huygens papers recently published are worth mentioning. They both are the outcome of several years of extensive efforts made by the GCMS team and the SSP team to conduct laboratory calibration experiments that were required to analyse and interpret the measurements at Titan. GCMS team paper (Niemann et al., J. Geophys. Res. 115, E12006, 2010) allowed retrieving the vertical profiling all the way to the surface in spite of haze, the noble gas measurements and a more accurate determination of some isotope ratios. The bonus was the surface results. Further demanding calibration work is in preparation to further analyse and interpret quantatively the surface measurements. The SSP team paper (Atkinson et al., Icarus 210, 843, 2010) involved laboratory penetrometry into room temperature surface analogue materials using a replica penetrometer to investigate further the nature of Titan's surface and examine the sensor's capabilities. The results are then compared to the flight instrument's signature and suggest the Titan surface substrate material consists mostly of sand-sized particles with a mean grain size 2 mm.

The next Cassini-Huygens PSG meeting will take place at JPL in Pasadena on 24-28 January 2011.

1.4 Rosetta

The scientific outcome of the Rosetta fly-by at asteroid (21) Lutetia was reported at numerous conferences and workshops. The scientific community showed such great interest in the fly-by that a large number of special sessions and invited plenary presentations were held between October and December 2010. A 3-day scientific workshop was held in October 2010 to review and discuss all measurements obtained during the fly-by at asteroid (21) Lutetia. The Rosetta instrument teams presented the status of their data analysis and the available results. Altogether 70 scientists attended the meeting representing the 17 instruments that were switched on during the fly-by. The physical and compositional properties of the asteroid and its environment were discussed on the basis of altogether 29 presentations. In addition, numerous splinter meetings took place in which the way forward was discussed in detail in view to understanding the measurement results obtained by the various instruments and deriving physical, compositional, and thermal properties of the asteroid on the basis of the available data. The splinter meetings were very fruitful, in that they also led to

agreements on how to proceed with common data analysis and combination of data. The achieved excellent results are currently being prepared for publication in peer reviewed scientific journals.

1.5 Venus Express

After having passed inferior solar conjunction end of October 2010, Venus is now near maximum solar elongation, which will occur mid January 2011. During these periods a small high gain antenna with limited performance is used for thermal reasons, limiting the amount of science that can be downloaded. As from end of January 2011, when the angle Sun-Venus-Earth becomes less than 90 degrees, the large high gain antenna will be used again and all instruments will be able to work at full data rate.

Due to the relatively large angular distance between Venus and the Sun as seen from the Earth during the period December 2010 - January 2011, Venus can be observed well by ground based observatories and spacecraft in Earth orbit. A dedicated campaign for coordinated Venus Express and ground based observations is taking place during this period. This has been done during the three last opportunities with maximum solar elongations and many valuable observations have been carried out. Particularly interesting this time is a set of three observations by the Hubble Space Telescope that are coordinated with observations by Venus Express. The main objective of this set is to combine large scale atmospheric dynamics studies (by HST) and high spatial resolution and spectroscopic observations (by VEX).

The Japanese Venus Climate Orbiter, Akatsuki, arrived at Venus on 7 December 2010, but unfortunately the orbit insertion manoeuvre failed, leaving the spacecraft in a 200 days period, heliocentric orbit. JAXA is investigating the cause of the failure and possible future scenarios. A possibility may be to make a second attempt of an orbit insertion in 2016 when the spacecraft meets up with Venus next. Future VEX observations will be modified to reflect the new situation.

A new generic model of planetary magnetospheres, developed by Echim et al. (PSS, in press, ISSN 0032-0633, 2011) has been tested by using data collected simultaneously by VEX at Venus and by Cluster at the Earth, thus representing similar solar conditions. The data verify that the model predicts the conditions around both these planets very well in spite of the very different magnetospheres. This marks an important step in the general understanding of planetary magnetospheres (see also section on Cluster).

A surprisingly high concentration of SO_2 at altitudes up to 90 km, as measured by Venus Express, has been explained by Zhang et al. (Nature Geoscience 3, 834, 2010) using a new model including the effect of photolysis of sulphuric acid. Interesting parallels can be drawn to the Earth stratosphere, as it has been proposed that such layers, artificially created, could be very efficient for mitigating global warming. Sulphuric acid droplets at high altitude would efficiently reflect sunlight and increase the albedo of the Earth and so reduce the global temperature.

1.6 Mars Express

Sindoni et al. (PSS, in press, 2010) from the PFS team have reported measurements of H_2O and CO atmospheric compounds acquired for more than two and a half Martian years, allowing to constrain better the behaviour and circulation of these species. A maximum in the water vapour density is measured during the Northern summer over the polar cap, due to the sublimation of H_2O ice. Afterwards, one can observe the water vapour migration toward tropical regions. A similar behaviour is repeated in the Southern hemisphere. A very strong depletion (by a factor more than two) of the non-condensable CO is related to the sublimation of CO_2 ice.

Many articles based on the MARSIS radar data have been published recently. Mouginot et al. (Icarus 210, 612, 2010) have reported the first global map of surface echo power at a frequency of 3–5 MHz. The map gives the dielectric properties of the materials down to a few decameters below the surface. Dielectric properties vary with latitude, with high values in mid-latitudes belts (20–40°) and lower values at both equatorial and high latitudes. Results at high latitudes correspond to the onset of water-ice occurrence within the regolith. The inferred volume of ground water ice is of 10^6 km^3, equivalent to a polar cap. The results at the equator could be explained by the presence of ice, deposited during a high-obliquity/high-humidity climatic excursion, that is currently sublimating at some depth and hydrating the overlying regolith.

In an article by Duru et al. (GRL 37, L23102, 2010) very unusual ionospheric reflections have been reported for the first time: they overlap (in frequency) with surface echos. This situation is in principle not possible if we assume the ionosphere to be horizontally stratified. This feature is being interpreted as the signature of strong horizontal density gradients present in the ionosphere near the terminator.

Lillis et al. (JGR 115, A11, 2010) deal with total electron content in the atmosphere derived from MARSIS. Interesting relationships are found between electron content, energetic particle events and solar extreme ultraviolet fluxes.

Gurnett et al. (GRL 37, L24101, 2010) have reported the results of a nearly five-year search for impulsive radio signals from lightning discharges in Martian dust storms using MARSIS. The search covered altitudes from 275 km to 1400 km and frequencies from 4.0 to 5.5 MHz with a time resolution of 91.4 μs and a detection threshold of 2.8×10^{-18} Watts m^{-2} Hz^{-1}. At comparable altitudes the intensity of terrestrial lightning is several orders of magnitude above this threshold. Although two major dust storms and many small storms occurred during the search period, no credible detections of radio signals from lightning were observed.

The 17 December 2010 issue of *Science* includes special sections highlighting the “Breakthrough of the Year and Insights of the Decade”. One of the top 10 is “Water on Mars”: the past decade's half-dozen Martian missions (including Mars Express) have made it clear that early in Mars history, liquid water on or just inside the planet did indeed persist long enough to alter rocks and, possibly, sustain the origin of life.

1.7 Chandrayaan-1

Most of the reporting period was spent to reprocess all the data with the updated SPICE data provided by ISRO. All data are now available in the format needed by the ESA-PSA (Planetary Science Archive). The SIR-2 data have been delivered, the SARA data are in the process of being validated.

Futaana et al. (JGR 115, A10248, 2010) have analyzed data from SARA ion spectrometer SWIM on 25 Jan 2009. During these observations the conditions of the Interplanetary Magnetic Field (IMF) were stable and the geometrical conditions of solar wind and magnetic field were relatively simple. SWIM observed three ion populations in addition to the nominal solar wind ions (protons and alpha particles). Observed backscattered protons and accelerated backscattered protons can be explained by single-particle motions in the IMF and the convective electric field. In addition, proton fluxes in the lunar wake region were detected. These have been already observed by Kaguya spacecraft (Nishino et al., GRL 36, L16103, 2009), but the previously proposed explanations for their source are not consistent with the SWIM observations. A new, one-dimensional model was developed to explain the nightside ion flux in the Moon's wake. While it does explain the existence of the flux, the predicted ion velocity is a factor 2 to 3 lower than the observations. The surface absorption effect and the negative surface potential of the Moon are possible reasons for the discrepancy.

A (not peer-reviewed) version of the data of the Terrain Mapping Camera and the Hyperspectral Imager is available at the ISRO website
(http://issdc.gov.in/CHBrowse/jsp/include/test1.jsp?para=/CHBrowse/html/home.html).

1.8 HINODE

Tripathi et al. (ApJ 723, 713, 2010) have presented evidence for impulsive heating of active region core loops. They have obtained emission measure EM(T) distributions from EIS observations and have compared those with theoretical EMs derived for three limiting cases: static equilibrium, strong condensation, and strong evaporation. The observed EM distribution is best explained by the strong condensation case, suggesting that a downward enthalpy flux plays an important role in powering the transition region plasma. They have identified as most likely source of the downflows the cooling and draining of plasma that has been impulsively heated by nanoflares, which supports the idea that the hot loops (with temperature of 3-5 MK) seen in the core of active regions are heated by nanoflares.

Guglielmino et al. (ApJ 724, 1083, 2010) have reported multi-wavelength observations of a magnetic flux emergence event, observed simultaneously with Hinode (EIS and XRT) and the Swedish Solar Telescope on La Palma. Their analysis supports the predictions of recent three-dimensional numerical simulations that energetic phenomena result from the interaction between emerging flux and pre-existing flux in the solar atmosphere.

Peter (A&A 521, A51, 2010) has studied the asymmetries of solar coronal EUV lines measured with EIS. The lines show enhanced emission in the wings and are best fit by a narrow line core and a broad minor component. The latter contributes 10-20% to the total emission and is about a factor of 2 broader than the core and strongly blue shifted up to 50 km s^{-1}. He has suggested that coronal structures consist of at least two classes that are not resolved spatially but only spectroscopically, and that the source regions of the minor component are contributing the major part of the heating and mass supply to the corona.

1.9 PROBA 2

Since November 2010, the PROBA2 spacecraft is in the yearly eclipse phase, resulting in a transition from UV-eclipse to visual eclipse to UV-eclipse every orbit. The duration of these eclipses peak around winter solstice and take about 30 minutes. Both SWAP and LYRA use these events to acquire valuable data when Sun light is traveling through the Earth atmosphere by the execution of several operation campaigns. LYRA data set will allow analysis of atmospheric composition of several atoms and molecules over altitude, e.g. the ozone composition.

Campaigns were also executed during the Geminid meteor shower peaking on 14 December 2010 and combined data analysis with radar, visual and rocket experiments executed in a dedicated campaign, also supported by the Science Directorate, is planned.

During the solar eclipse that was observed as a partial eclipse over Europe on 4 January 2011, SWAP and LYRA observed the eclipse 3 times - basically due to the fact that PROBA2 orbits three times during the eclipse duration. Corresponding web releases were prepared. A SWAP movie found its way into the Stargazing LIVE program of the BBC on the evening of the 4 January 2011.

Seaton et al. (ApJ Letters 727, L10, 2011) have presented a three-dimensional reconstruction of an eruption that occurred on 3 April 2010, using observations from SWAP on board PROBA2 and SECCHI on board STEREO. The event unfolded in two parts: an initial flow of cooler material confined to a height low in the corona, followed by a flux rope eruption higher in the corona. Mass

off-loading from the first part triggered a rise and, subsequently, catastrophic loss of equilibrium of the flux rope.

Gantois et al. (ESA Bulletin 144, 2010) have given an overview of the PROBA2 project, ground segment, flight segment and Science Centre. Following an organizational overview of the project, the mission is described and spacecraft information given at system and sub-system level. Besides a description of the technology payload of the spacecraft, the scientific instruments are described and room is given for first scientific results.

2 Projects under development

1.10 BepiColombo

The joint MESSENGER – BepiColombo Workshop on Exploring Magnetosphere-Exosphere Coupling at Mercury was held on 2-5 November 2010 in Boulder, Colorado. This thematic workshop is the second in a series of such meetings convened by the MESSENGER and BepiColombo science teams to prepare for MESSENGER orbital operations and to plan for the BepiColombo mission.

At the last BepiColombo SOWG (24 November 2010) work on the Science Activity Plan has started. Spacecraft resources (power and data rate) vs. requirements were presented to the teams. First operational limitations have been discussed with the instrument teams. Possible power limitations at perihelion and the impact of the reduced data downlink indicate that measures need to be taken by all parties to improve the situation. Teams will work on a prioritization of measurements and on more realistic operational scenarios.

On 18 March 2011 the NASA MESSENGER spacecraft will be put into an orbit around Mercury and start science operations for about one year. MESSENGER will be the first spacecraft in an orbit around Mercury ever and provide new insights into the planet. BepiColombo will benefit from these results and provide the next level of details by performing global and more comprehensive studies to better understand the evolution and history of this extreme planet.

Prepared by:
L. Colangeli
(Head SME-SM)
with inputs from Project Scientists