7th SSEWG Meeting
30-31 May 2011

Report

Solar System Missions Division (SRE-SM)

1. Missions in Orbit

1.1 SOHO

On 12 April 2011 at 23:22:31UT, after successful completion of the cross-calibration with SDO/HMI (Solar Dynamics Observatory / Helioseismic and Magnetic Imager), MDI (Michelson Doppler Imager) was commanded to stop taking science data. MDI has operated exceptionally well for more than 15 years and has produced data that form the basis of almost 1500 papers in the refereed literature.

Chen et al. (ApJ 728, 147, 2011) have presented a novel method to measure the radial profile of the Alfvén speed and the magnetic field strength in the outer corona. They have analyzed LASCO (Large Angle and Spectrometric Coronagraph) observations of streamer waves, which they interpret as fast kink body waves generated by the impact of a fast Coronal Mass Ejection on the streamer. The radial profile of the Alfvén speed is determined from the phase speed and the electron density from inversion of LASCO pB (polarised brightness) data. From those two measurements they determine the radial profile of the magnetic field in the outer corona.

Hathaway & Rightmire (ApJ 729, 80, 2011) have studied the variations of the axi-symmetric transport of magnetic elements on the Sun from 1996 to 2010 using MDI magnetograms. They have found that: (i) the differential rotation is weaker at maximum than at minimum; (ii) the meridional flow is faster at minimum and slower at maximum; (iii) the average latitudinal profile is largely a simple sinusoid that extends to the poles and peaks at about 35° latitude; and (iv) there are polar countercells (equator-ward flow at high latitudes) in the south from 1996 to 2000 and in the north from 2002 to 2010.

McIntosh et al. (ApJ 730, L3, 2011) have measured solar cycle variations of the length scale of the supergranular network using MDI and EIT (Extreme ultraviolet Imaging Telescope) data. They find a clear solar cycle signal and a small difference between the minima of cycle 22/23 and 23/24. Given that the modulation of the supergranular scale imprints itself in variations of the Sun's spectral irradiance as well as in the mass and energy transport into the outer atmosphere and the solar wind, this result is important for our understanding of the impact of the quiet Sun on the heliosphere.

Del Zanna and Andretta (A&A 528, A139, 2011) have presented EUV irradiances for the Sun obtained between 1998 and 2010 from CDS (Coronal Diagnostic Spectrometer) full-Sun radiance observations. These measurements represent the first set of EUV spectral observations spanning a full solar cycle. Lines formed in the transition region show very small changes over the solar cycle, with the exception of the helium lines. Lines formed around 1 MK (million Kelvin) change by a factor of about 5, and for hotter lines (2.5 MK) the variability increases to about 40. Future work will focus on improving models of the solar EUV irradiance, with the goal of providing reliable input to climate models and to models of the effects of the magnetic activity of young stars (including the Sun) on planets. Currently, CDS is the only instrument in orbit capable of measuring radiances over the full-Sun in lines spanning the entire temperature range of the solar corona, from the low transition region to flare temperatures.

1.2 HINODE

De Pontieu et al. (Science 331, 55, 2011) have combined SDO/AIA (Solar Dynamics Observatory/Atmospheric Imaging Assembly) and Hinode SOT (Solar Optical Telescope) and EIS (Extreme Ultraviolet Imaging Spectrometer) observations to reveal a ubiquitous coronal mass supply in which chromospheric plasma in fountain-like jets or spicules is accelerated to velocities of 50 to 100 km s^{-1} upward into the corona, with much of the plasma heated to transition region temperatures (20,000 – 100,000 K) and a small but significant fraction to temperatures above 1 MK. They estimate that these events carry a mass flux density of 1.5×10^{-9} g cm^{-2} s^{-1} and an energy flux density of $\sim 2 \times 10^{6}$ erg cm^{-2} s^{-1} into the corona, which are of the order required to sustain the energy lost from the active region corona. The authors conclude that these events are likely to play a substantial role in the coronal energy balance and highlight the importance of the chromosphere (the interface region between photosphere and corona) for a better understanding of heating in the solar atmosphere.

Van Doorsselaere et al. (ApJ 727, L32, 2011) have used EIS observations of slow magneto-hydrodynamic waves in the solar corona to measure for the first time the value of the effective adiabatic index as 1.10 ± 0.02. This confirms that the thermal conduction along the magnetic field is very efficient in the solar corona. They also measured the thermal conduction coefficient from the phase lag between the temperature and density perturbations and obtained a value compatible with classical Spitzer conductivity.

Socas-Navarro (A&A 529, A37, 2011) has presented the first high-resolution three-dimensional model of the solar photosphere that is based on the inversion of spectro-polarimetric observations with Hinode/SP. Previous 3D models were all based on numerical radiation hydro-dynamical simulations. Due to the high spatial resolution of Hinode observations, the major granular components are resolved. The derived model, therefore, does not require micro- or macro-turbulence to properly fit the widths of the observed spectral lines. The model is now publicly available for use by the community.

Berger et al. (Nature 472, 197, 2011) have combined optical and EUV observations obtained with Hinode/SOT and SDO/AIA to study the thermodynamics of polar crown filaments. They find that the low-density coronal cavity contains plasma at temperatures in the range $(2.5\text{-}12) \times 10^{5}$ K, which is 25-120 times hotter than the overlying prominence. These observations suggest that the coronal cavity-prominence system supports a novel form of magneto-convection in the solar atmosphere, challenging current hydro-magnetic concepts of prominences and their relation to coronal cavities.

1.3 Cluster/Double Star

Marklund et al. (PRL 106, 055002, 2011) have used data from Cluster's Auroral Acceleration Region campaign. This is the first time this region has been sampled simultaneously by more than one satellite and has allowed the electric potential structure (the heart of the acceleration) to be mapped. The dual observations reveal spatial and temporal variations in the electric fields and associated particle signatures. For the first time it has been possible to constrain the size and longevity of these regions. The data show that the electric field structures measured at least 800 km across and remained stable for at least 5 minutes. The new results do not yet provide a complete explanation of the dynamics of the aurora, since the Cluster instruments are not optimised for measuring this region, but they provide important constraints on how these structures are created.

Farrugia et al. (JGR 116, A02204, 2011) have used the multi-spacecraft capability of Cluster to probe the complex structure of Flux Transfer Events (FTEs) on the dayside magnetopause. FTEs are bundles of reconnected flux which were originally identified in 1978, but only with Cluster and Double Star data have the complex topology of these features been revealed. The paper highlights the benefit of multi-point measurements in probing the reconnection in the heart of these features

and recognises the importance of Cluster to the upcoming NASA Magnetospheric Multiscale (MMS) mission.

Kronberg et al. (JGR 116, A02210, 2011) have reported on observations of energetic ions upstream of the bow shock, connecting measurements from Cluster, GEOTAIL, and STEREO A and B, with spacecraft separations reaching over 400 Earth radii. Data show evidence of magnetospheric ions upstream of the bow shock during geomagnetic disturbed periods and, although not ruling out bow shock acceleration, the paper shows that the most intense fluxes of energetic ions are likely to be of magnetospheric origin.

The European Cluster Assimilation Technology (ECLAT) FP7 project was kicked off at a meeting held at FMI on March 23-25, 2011. The programme aims to produce supporting data sets for the Cluster Active Archive (CAA) from other space- and ground-based observatories. It will also provide data mining routines, refined data products and software tools for their visualization, and develop existing European magnetospheric modelling infrastructure to put the observational data into context. This activity is an indication of the high regard and level of interest from the community to the CAA and will be greatly beneficial to the community.

1.4 Mars Express

Another Phobos flyby campaign took place in December 2010 – January 2011. The closest flyby occurred on January 9, 2011 at a distance of 111 km from the center of the moon. This is the third closest flyby Mars Express has performed. High-resolution images of the southern hemisphere of the moon and of the envisaged Phobos-Soil Russian mission landing site were acquired and published very quickly. The solar superior conjunction started a few days later. Solar corona experiments were successfully performed at conjunction entry and exit.

A workshop entitled "Mars atmosphere: modelling and observations" was held in Paris on February 8-11, 2011. It gathered ~130 participants and was a real success. The most discussed topics were the CO_2 ice clouds (Mars Express discovery), the new nightside O_2 emission (Mars Express discovery), and the past climate. The impact of the Mars Express SPICAM and OMEGA results was significant.

A discussion was organised at the Mars Express Science Working Team meeting (ESAC, May 3-4, 2011) on the remaining fuel usage to support the NASA Mars Science Laboratory (MSL) Entry Descent and Landing event in August 2012 and/or to optimize for a close Phobos flyby in April 2012. The team recommended to support MSL only, and to re-assess the possibility for a flyby at a later stage.

Stenberg et al. (GRL 38, L09101, 2011) have investigated the penetration of α-particles (He^{++} ions) into the Martian atmosphere. They conclude that solar wind α-particles contribute to the helium observed in the atmosphere. Studying the helium balance in a planetary atmosphere provides useful information on the formation of the solar system.

Ansan et al. (Icarus 211, 273, 2011) have used Mars Express HRSC and OMEGA data to characterise the stratigraphy, mineralogy, and origin of layered deposits inside the 174 km diameter Terby Crater (28° South, 74° East). This is a very interesting crater displaying, in a single location, geologic features that represent three main periods (Noachian, Hesperian, Amazonian) on the planet.

A literature survey over the past 10 years has been published in May 2011 on "Science watch" (http://sciencewatch.com/ana/st/planet/papers10yr/). The 20 most-cited papers in planetary

exploration include a strong showing of papers from Mars Express mission. Four articles from OMEGA and one from PFS are amongst the top 10 articles.

Five web stories have been published on the ESA portal in 2011. The dedicated Phobos blog was reactivated at the occasion of the close flyby in January. The Phobos image was 'Astronomy picture of the day' on 24 January.

1.5 Venus Express

The tenth radio occultation season for Venus Express occurred between January and March 2011. In this phase approximately every second orbit is used for determining the effect ionosphere and atmosphere have on the propagation of the communication signal between the spacecraft and Earth. Each measurement results in a vertical profile of the electron density in the ionosphere and the temperature and pressure in the atmosphere. To date more than 350 such profiles have been acquired, at different latitudes and local times, more than from all previous spacecraft at Venus added together.

The fifth atmospheric drag campaign, combining radio tracking and torque measurements at low altitudes has just started and the increasing solar activity has been clearly detected, manifesting itself by inflating the atmosphere at Venus. These unique observations are very valuable for determining the density in an altitude range difficult or impossible to access with other means.

On April 27, 2011 one of the star trackers was used for demonstrating the capability of detecting asteroids as a background activity. Asteroids 1 Ceres and 13 Egeria were clearly identified and their motion between two exposures, separated by 8 hours, could be easily determined.

An intense collaboration with Japanese scientists has been initiated after the unfortunate failure to insert the Akatsuki spacecraft into Venus orbit. The collaboration serves a dual purpose; the Venus Express teams get enhanced capability of analysing their data, and the Japanese teams, lacking the data from Akatsuki, get fresh data from Venus Express. A dedicated workshop in Chiba planned for late May has been moved to the autumn following the major earthquake/tsunami in January.

Luz et al. (Science 332, 577, 2011) have described the southern polar vortex using VIRTIS spectral imaging data, and in particular the new discovery that the vortex rotates about a point offset from the geographical pole with 2-4 degrees. This point is shown to rotate around the geographical pole at a period of about 5-10 Earth days. These findings demonstrate the importance of studying the polar regions for acquiring a better understanding of the global dynamics and the super rotation of the atmosphere. They provide clues of how the transfer in latitude of angular momentum can take place.

1.6 Rosetta

The most important outcome of the fly-by at asteroid (21) Lutetia (occurred on July 10, 2010) has been summarized for publication in Science Magazine and is currently under peer review. In addition, the latest findings were presented in a special session on the results of the Lutetia fly-by, which took place at the annual meeting of the European Geophysical Union in April 2011. A number of presentations about asteroid Lutetia were given at the 42nd Lunar and Planetary Science Conference in March 2011.

The scientifically most relevant surface features of asteroid (21) Lutetia have received official names by the International Astronomical Union (IAU). The proposal of the OSIRIS PI team was approved with one minor change by the IAU Working Group for Planetary System Nomenclature (WG-PSN) on April 5, 2011. In total, 18 craters, 1 dorsum, 2 fossae, 3 labēs, 8 regiones, 2 rimae, and 2 rupēs have received names. The asteroid surface was divided into 8 regiones, of which the

one not visible to Rosetta during the fly-by was named "Goldschmidt Regio" after the discoverer of the asteroid. The IAU naming committee further agreed that the names of all surface features on (21) Lutetia should be chosen from three categories all related to the time when the town of Lutetia existed; whereby craters are named after cities, regiones after provinces of the Roman Empire, and other features after rivers at the time of Lutetia (52 BC – 360 AD).

A set of activity parameters has been established from telescopic observations of comet 67P/Churyumov-Gerasimenko in preparation for the scientific measurements during the comet phase. The parameter set covers values from a pre-perihelion heliocentric distance of 3.5 AU down to 1.5 AU heliocentric distance.

1.7 Cassini-Huygens

The Cassini Participating Scientist Program was launched jointly by ESA/NASA/ASI, as an extension of the Cassini Data Analysis Program (CDAP). An AO has been released on April 12, 2011.

The Cassini orbiter's orbit remains close to the equatorial plane of Saturn, as planned for the so-called "Equatorial Phase 1" lasting until May 2012. The primary science objectives of this phase are Saturn, its magnetosphere and its moons. Two milestones of the mission were achieved: on February 18 and on April 19, 2011 the 74^{th} and 75^{th} Titan flybys were performed at 3651 km and 10053 km altitude, respectively, and were dedicated to the study of the magnetic environment of Titan, in particular its induced magneto-tail.

Howett et al. (JGR 116, E03003, 2011) have used CIRS (Composite Infrared Spectrometer) temperature measurements to show that the amount of heat released at Enceladus south pole through the "Tiger Stripes" is one order of magnitude higher than expected from previous theoretical studies. A proposed explanation relies on temporal variation of the Saturn-Dione-Enceladus orbital resonance pattern leading to periods of time with increased heat production below the moon's surface. This has direct implications on constraining models predicting the existence of a liquid water layer below the moon's surface.

Turtle et al. (Science 331, 1414 2011) have reported a highlight in Titan's exploration: the authors correlate for the first time seasonal methane rain-fall with varying surface morphology by carving the 'dry' channels landscape previously observed at low latitudes.

Hedman et al. (Sciencexpress, 10.1126/science.1202238, 2011) have shown that ripples observed with the visible camera in the inner Saturn's C ring are related to collisions with cometary fragments 10 to 30 years ago. This result confirms that exogenous material from interplanetary space, likely to bear dark silicates and carbonaceous compounds, can make its way onto Saturn's rings. This has far ranging implications for constraining evolutionary models of the main ring system, which appears to be surprisingly young in terms of composition (nearly pure water ice).

Pryor et al. (Nature 472, 331, 2011) have demonstrated for the first time that Saturn and Enceladus are connected by an electrical current, under the form of electrons and protons streaming from the moon toward Saturn along Saturn's magnetic field lines. Evidence of this connection has been found by identifying a so-called "auroral footprint" in Saturn northern hemisphere glowing in UV light and corresponding beams of energetic particles aligned with the field lines near Enceladus.

1.8 Chandrayaan-1

Lue et al. (GRL 38, L03202, 2011) have discussed the influence of lunar magnetic anomalies on the solar wind and on the lunar surface. The solar wind is normally absorbed by the lunar regolith, due to the lack of a Moon strong global magnetic field. However, there are local areas of magnetic crust,

called magnetic anomalies. These are expected to interact with the solar wind, possibly even forming bow shocks. Data from SARA/SWIM (Solar Wind Monitor) have been used to produce maps of solar wind proton fluxes deflected by the magnetic anomalies. The authors find deflection efficiencies of 10% up to 50% over the large-scale (> 1000 km) regions of magnetic anomalies. Thus, they could show that these anomalies indeed act as a magnetosphere-like obstacle, affecting the upstream solar wind and reducing the space weathering effects.

Bugiolacchi et al. (Icarus 213, 43, 2011) have used data from the SIR-2 infrared spectrometer to study the mineralogy in the central section of Copernicus crater. They have used three different spectral classification schemes. The results show that all methods provide comparable spectral classes, which can be used to interpret the geology of the crater. The authors find clear olivine absorption characteristics in the central peaks, on the northern crater walls and in one location at the border with the south rim. The pyroxenes are asymmetrically distributed across the crater, supporting the hypothesis that the impact occurred on a geologic boundary region.

1.9 PROBA-2

On February 15, 2011 at 02:00 UT, the SWAP (Sun Watcher using Active Pixel System detector and Image Processing) and LYRA (Lyman Alpha Radiometer) detectors observed a X2.2 flare, the largest flare since 2006. Space weather alerts were given by the Solar Influence Data Centre (SIDC), which also bases their predictions on SWAP and LYRA data. No storm conditions took place due to the northerly direction of the arriving interplanetary magnetic field lines.

On March 10, 2011, the availability of the LYRA calibrated data was announced. Since then, SWAP and LYRA engineering, quick-look and calibrated data are available to the scientific community within 1 hour after each of the ten daily downlink passes.

The continuation of the PROBA-2 Guest Investigator program was announced begin of May 2011 at the web portals of ESA and the Royal Observatory of Belgium. The announcement was also covered within SolarNews.

Cessateur et al. (A&A 528, A68, 2011) discuss the possibility of reconstructing the solar irradiance in the UV, based on a small number of spectral pass-bands. The analysis takes into account data from GOES, TIMED, SDO, PROBA-2, and PICARD. The authors conclude from the statistical analysis that as few as four pass-bands are sufficient to reconstruct the UV solar irradiance between 28–280 nm with a relative error of about 20%. The paper mentions the current use of LYRA data to reconstruct the solar spectral variability in near-real time.

2. Missions under development

2.1 BepiColombo

The integration of the instruments onto the MPO STM and the integration of the instrument electrical models on the engineering test bench are ongoing. The MPO STM thermal vacuum test is foreseen for July 2011 at the Large Space Simulator in ESTEC.

An MPO Science Working Team meeting was held on March 31, 2011. The work on the BC Science Activity Plan is ongoing. It will have to demonstrate that the science goals of the mission can be achieved within the available spacecraft resources.

The “BC Surface Science Working Group” held a workshop mid April in Berlin. Discussion focused on surface related topics and presentations were given by representatives from the NASA MESSENGER team on their science approach and the geology of Mercury after 3 flybys. The MESSENGER Mercury orbit insertion was successfully performed on 18 March 2011.

After the disasters happened in Japan since March 11, 2011 we are happy to report that all of the people working on the BepiColombo MMO were OK. Planned power outages after the disasters delayed some of the analysis calculations for MMO.

3. Missions under study

3.1 Solar Orbiter

A major event during the reporting period was NASA's announcement in early March that, as a consequence of budgetary problems, their contribution to the Solar Orbiter payload will have to be reduced; specifically, only two of the four planned investigations are able to be funded beyond the end of the current Phase-A contracts (June 2011). The instruments that will not be funded are the Suprathermal Ion Spectrograph (SIS, part of the European-led Energetic Particle Detector suite) and the US-led Spectral Imaging of the Coronal Environment (SPICE) EUV spectrometer. Following this announcement, an ESA Review Panel was established to: a) analyze the impact of the NASA instrument de-scope on the science return of Solar Orbiter; b) assess, where possible, proposed mitigation measures to recover the major Solar Orbiter scientific objectives in the absence of the above payload elements; and c) recommend, where appropriate, potential ways forward to ensure that the major Solar Orbiter scientific objectives will be met. The Panel, under the Chairmanship of Prof. L. Culhane, met on 27 April in ESTEC and concluded that the basic measurement capabilities of SIS and SPICE are central to the achievement of the scientific goals of the mission and urged the ESA Executive to explore European-led solutions to retain these capabilities. In parallel, all four US instrument teams have continued their cost-reduction / de-scope studies and have submitted the results in the form of "white papers" to NASA HQ.

The 4th Solar Orbiter Workshop took place in Telluride, CO, on March 27-31, 2011. The meeting, which was attended by more than 120 participants, focused on the recent developments in areas of science of relevance to Solar Orbiter, as well as assessments of studies that need to be undertaken in preparation for the analysis of the unique data expected from the mission. A special session was devoted to synergies with NASA's Solar Probe Plus mission and other heliophysics missions that are currently in the planning stage. At an executive meeting held during the Workshop, the Solar Orbiter Science Working Team drafted a resolution in which they expressed a deep concern regarding the potential loss of measurement capabilities that make major contributions to many of the scientific goals of the mission if SIS and SPICE were to be removed from the payload, and in which they strongly urged NASA and ESA to take all necessary steps to maintain these important scientific capabilities for Solar Orbiter.

3.2 Plato

All members of the PLATO Science Team (PST) have now been appointed. The PST is currently focusing on the preparation of the Phase-A Study Report ("the Red Book").

The "Solicitation to the PLATO Mission Consortium for a Documentation Package for the Implementation Phase" was sent to the PMC on the April 29, 2011 with a due date of July 12, 2011.

The two parallel industrial definition studies are nearing completion. No fundamental issues have been identified. To formally close Phase-A studies, a PLATO Preliminary Requirements Review (PRR) is being carried-out between May 16 and June 14, 2011. The PRR objectives are to demonstrate that the Mission definition has reached a maturity level that is compatible with the start of the Implementation Phase preparation. More specifically, the PRR must confirm: (1) the mission System Requirements, (2) the programmatic feasibility of the space segment, and (3) the technical feasibility of the mission, through appropriate definition and modelling. The PRR marks the formal completion of Phase-A studies.

The development of PLATO specific CCDs is also progressing well through a contract with E2V. Under this contract, one batch with 24 CCD wafers will be produced. From each wafer one normal and one small chip will be extracted. The former will be used for environmental testing, while the small chips will be used in radiation testing. One additional CCD (mechanical device) has already been delivered to the PLATO Consortium for use in their development programme.

The PLATO Science Management Plan was updated and submitted to the AWG on May 11, 2011.

3.3 Jupiter System mission (Laplace)

The public presentation of EJSM-Laplace – the ESA-NASA two-spacecraft mission to the Jupiter system – took place on February 3, 2011 in Paris together with the other two L-mission candidates. The presentation focused on the science goals, mission architecture and scenario, measurement requirements and model payload of the European flight element – Jupiter Ganymede Orbiter (JGO), as well the summary of the industrial studies by three contractors.

Following the publication of the US budget request for FY2012 and NRC Planetary Decadal Survey in February-March 2011, which implied that NASA would not be able to contribute to any of the ESA L-class missions as planned, ESA had announced a new approach calling for re-formulation of all three L-missions into European led concepts. For EJSM-Laplace this meant that the NASA's Jupiter Europa Orbiter (JEO) would not fly.

In mid-April 2011 ESA appointed the Science Study Team (SST) for the new European led Jupiter System mission concept. Its major task is to re-formulate the science case, to re-structure the mission and to study if and which of the original science goals of EJSM-Laplace can be achieved by a European led mission. This work is supported by an ESA study team. The SST mandate will terminate in February 2012. Dr. Joan Salute was nominated as NASA observer to the European SST.

The SST emphasized that the Jupiter Ganymede Orbiter (JGO), the ESA flight element of EJSM-Laplace, is well defined, scientifically justified, technologically feasible and financially affordable for Europe mission, which can deliver L-class science. The mission has great scientific potential and covers all fields of planetary science including geology, geophysics, atmospheric and magnetospheric physics and habitability that makes it a truly interdisciplinary endeavour with full involvement of the planetary community in Europe. The mission has a feasible implementation schedule with the launch in 2022 if a down-selection is made before mid-2012.

Recovery of the science goals otherwise lost due to the cancellation of JEO will be based on tuning of the JGO mission profile, possible modifications to the baseline spacecraft design and some adjustments of the payload. The ongoing mission revision is focusing on the following aspects: (1) definition of science requirements for Europa observations (number and properties of flybys, velocities, illumination conditions, etc.) in order to achieve top priority science goals at the moon; (2) evaluation of the mission resources (mass, radiation and planetary protection) needed for the Europa phase; (3) review of the JGO scenario in order to trade scientific return between the current profile and additional Europa science.

The SST plans to finish the study by the end of August 2011 and to present the results at an open science community workshop. The new mission Assessment Report will be issued by the end of November 2011.

3.4 Marco Polo-R

This is a sample-return mission from a primitive asteroid, proposed in response to the Cosmic Vision M3 mission call. It was selected for further study by ESA's advisory structure at the beginning of 2011. The proposal is based on the previous study for an asteroid sample return mission, Marco Polo. The main differences are that it is now proposed as collaboration with the US rather than with Japan. The target is changed to a primitive *binary* asteroid, namely 1996 FG_3. The science goals are linked to the following basic questions: 1. What were the processes occurring in the early solar system and accompanying planet formation? 2. What are the physical properties and evolution of the building blocks of terrestrial planets? 3. Do NEAs of primitive classes contain presolar material yet unknown in meteoritic samples? 4. What are the nature and the origin of the organics in primitive asteroids and how can they shed light on the origin of molecules necessary for life? These science goals will mainly be achieved by returning several tens of grams of sample from the asteroid to the Earth for laboratory investigations. In addition, instruments on the spacecraft will provide additional information on the geological context of the sample.

The Science Study Team has been selected and consists of ten scientists from all over Europe. An internal Concurrent Design Facility (CDF) study will start on Aug 23, 2011. To prepare this study, some mission analysis activities have started. Industrial activities on proximity operations around asteroids are already ongoing; first results on the operations around a binary target are expected from this study. The advantages of going to a binary object are that much more information on mass, shape, and rotation periods of the objects are available from ground-based observations. Precise measurements of the mutual orbit and rotation state of both components can be used to probe higher-level harmonics of the gravitational potential, and therefore internal structure. The dynamical evolution driven by the YORP (Yarkovsky–O'Keefe–Radzievskii–Paddack)/Yarkovsky thermal effects can be more easily studied. The possible migration of regolith on the primary from poles to equator allows the increasing maturity of asteroidal regolith with time to be expressed as a latitude-dependent trend, with the most-weathered material at the equator matching what is seen in the secondary.

3.5 EChO

The EChO ESA Study Team has been established in March 2011 and work has started on the assessment study. The EChO science team has been appointed and the team activities started with a kickoff telecon/introductory briefing on May 3, 2011. Work is ongoing within both the study and science teams to prepare for the Concurrent Design Facility (CDF) sessions that will take place in June. Science requirements are currently under definition and iteration amongst the science team, with the science requirements document (SciRD) to be finalised after the first meeting at ESTEC of the science team on May 23, 2011; payload and mission requirements will be derived from the preliminary science requirements to realise the payload and mission requirement documents that will, along with the SciRD, form the starting point of the CDF study.

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