Report to AWG#148

Compiled by J. Clavel, from inputs provided by Project and Study Scientists – 15 May 2012

3 - Euclid Mission status: Rene Laureijs

Both industrial teams have now finalised the definition studies (Phase A and Phase B1) and delivered their final presentations at the Baseline Design Consolidation Reviews (BCDRs) in March. A small contract extension was initiated to prepare for the intended ESA procurement scheme. The VIS and NISP Instruments Design Consolidation Reviews (IDCRs) were held in April. The reviews verified that all issues which had been identified in the course of previous reviews had been properly addressed and closed before entering the project implementation phase.

ESA also reviewed the solicitation proposal from the Euclid Mission Consortium (EMC) for the Euclid implementation and operation phases. The proposal had been submitted in July and September 2011. The review started immediately after the selection of Euclid by the SPC in October 2011. Four panels examined respectively the science management, the payload, the science ground segment elements and the programmatic aspects of the EMC proposal to assess whether they had reached the level of definition, the maturity and the stability necessary to proceed with the mission implementation. The evaluation committee concluded that management plans, consortium structure and financial plans are generally adequate. They also consider that the EMC implementation plan for the Science Ground Segment is sufficiently complete and credible for this stage of the project. The committee nevertheless identified a number of open issues which needed to be resolved before mission adoption, namely (1) a demonstration that the VIS scientific objectives remain achievable after CCD charge transfer inefficiencies and radiation damage are properly taken into account, (2) the restoration of proper performance margins for both VIS and NISP, (3) a reassessment of the instrument development schedules in line with the project schedule needs, and (4) the demonstration of adequate technology readiness for some items. The EMC reply is due before the end of May.

The Euclid Project Team at ESA is being appointed in preparation for the next phase of the mission. Once the mission is hopefully adopted by the SPC in June, the first task will be to issue the Invitation To Tender (ITT) for the procurement of the payload module in July 2012.

10 - Project under development - Gaia: Timo Prusti

The alignment of the two telescopes on the Payload Module (PLM) is close to completion. The Radial Velocity Spectrometer (RVS) is now mounted onto the PLM and the RVS alignment measurements are carried-out for the whole optical chain combining the telescopes and the instrument. The estimated in-flight wave front error is close to requirements, but further analysis is needed to fully understand the astigmatism term of the Legendre polynomial expansion of the model used to describe the alignment test measurements. The Focal Plane Assembly (FPA) successfully passed the thermal-vacuum tests. The electronics behind one CCD which consumed excessive power already before the tests had to be switched off. Since the tests did not reveal any new problem, the faulty electronics was replaced and the FPA was delivered to the PLM team for integration.

With the delivery of the Basic Angle Monitor (BAM) and the Phased Array Antenna (PAA), all flight units have now been provided to Astrium for integration. Testing and space component alerts have revealed weaknesses in the Clock Units, Payload Data Handling Units and the Bipod Release Mechanisms. In all three cases, technical solutions have been found and are currently being implemented into the flight units. Mechanical testing of the PLM and thermal-vacuum testing of the Service Module will take place during the summer.

Following its endorsement by the AWG, the Gaia Intermediate Data Release policy was incorporated into the operations plans by the Gaia Data Processing and Analysis Consortium (DPAC). The resulting Gaia Data Release scenario was subsequently agreed between the Gaia Science Team (GST) and the DPAC Executive. The scenario, which contains the best pre-launch estimates of the intermediate releases schedule and content, will be presented to the AWG.

12 - Status report on M-class missions assessment studies

12.1 - SPICA: Kate Isaak

The nominal term of the SPICA Science Study Team (SST) expires in June 2012. All members have expressed an interest in continuing to participate in the SST for the proposed one year extension period and formal invitations will be sent shortly. The letter of agreement for exchange of technical information and products between JAXA and ESA was extended for a further 2 years.

The SAFARI detector system requirements and progress review took place in Utrecht on 7-9 March. The Board chaired by Albrecht Poglitsch (MPE), included European and US detector experts as well as JAXA and ESA appointed specialists. Satisfied with the progress achieved since the detector technology down-select in June 2010, the Board concluded that there were no fundamental reasons why the SAFARI detector programme would fail. It urged the SAFARI team to consolidate the detector performance requirements in consultation the SAFARI science team.

The Risk Mitigation phase (RMP) is well under way in Japan. During this phase, JAXA are updating and consolidating the design of the spacecraft, with hardware prototyping and tests where needed. JAXA formally requested ESA and the SAFARI consortium to support the RMP. The technical issues being addressed include: consolidation of thermal allocations; mechanical design, performance and interfaces; electromagnetic compatibility and interferences; end-to-end optical performance and interfaces, and pointing and disturbance control. The RMP is scheduled to run until spring 2013. Assuming successful completion of the RMP, the invitation to tender (ITT) for the implementation phase will be released to industry.

As a consequence of the RMP, the date by which the Focal Plane Instrument (FPI) suite needs to be frozen was relaxed by about one year and the FPI Review was delayed accordingly. Reports from the science, engineering and programmatic panels are available and the Board Report is currently being finalised. The Board will issue its final recommendation on the composition of the SPICA instrument suite to the four agencies (JAXA, ESA, Korea, and NASA) by early 2013, following a delta-review next fall.

The twice-yearly meeting of the SAFARI consortium took place in Groningen over the period 12-15 March. Discussions centred on the SPICA and SAFARI science case update, consolidation

of the SAFARI scientific requirements, the need for narrow band and neutral density filters, observing modes and calibration requirements. An activity to explore synergies between the Euclid and SAFARI deep surveys was initiated under the leadership of Huub Roettgering (Leiden). The SAFARI Consortium steering committee endorsed a new organisational structure with well identified topical science working groups. Pending the appointment of a SAFARI project scientist, Frank Helmich (SRON) continues in an "acting" role.

Philippe Gondoin, former Euclid study manager, took over the role of SPICA study manager

12.2 - EChO: Kate Isaak

At its 13-14 February Meeting in ESTEC, the EChO Science Study Team (SST) discussed the impacts of stellar activity on EChO observations, reviewed and updated the mission reference sample, the signal-to-noise ratio requirements, the sub-division of the EChO waveband and calibration needs. Updates to the radiometric model description were also discussed and subsequently implemented.

SST members Ribas and Micela continue to develop independent simulations of the multi-wavelength signature of stellar spots and activity on EChO time series up to 16 microns and possible correction techniques using data from the visible channel. The removal of stellar activity signatures from EChO spectra using Independent Component Analysis (ICA) techniques is the subject of a separate investigation by science team member Tinetti.

A detailed comparison of the three EChO radiometric models developed respectively by ESA, the German and the UK Consortia has been completed. The radiometric model itself is also being upgraded to confirm that the ideal mission reference sample and known EChO candidate targets can be observed at the required signal-to-noise ratio during the nominal mission duration.

Composed of members of the SST and of the two instrument consortia, a working group has been appointed to define the architecture of the EChO science ground segment. It includes experts from the Herschel SPIRE and PACS instrument teams.

Ten different optical layout of the EChO telescope are currently being reviewed and compared for their respective merits and short comings, including on/off axis and focal/afocal designs. A baseline design will be selected by the end of May for the remainder of the study.

12.3 - LOFT: David Lumb

The two parallel industrial study contracts were kicked-off in late January. The first progress meetings focussed on clarifying the mission requirements. Both contractors confirmed that a Vega launch, as assumed in the original proposal, would reduce the effective area of the Large Area Detector (LAD) by 30 to 50%. After careful consideration, the Science Team (ST) concluded that most of the original science goals could not achieved by increasing the exposure time to reach the same signal to noise ratio since, in most cases, this would exceed the burst coherence time. Given the relatively modest cost increase of a Soyuz launch, the ST decided that a major descoping of the scientific case was not justified and agreed that the Vega launch option would only be studied on a best effort basis. The science team has also been requested to justify a flux response stability requirement which replaces a previous global stability requirement but is more stringent by two

orders of magnitude, albeit over a restricted frequency range.

Both industrial teams have already warned that thermal stability and eventual operating temperature requirements would be difficult to achieve. The instrument consortium was therefore requested to review the temperature required for mitigation against potential radiation damage. To extend the galactic centre visibility window, the payload team is also investigating the possibility of relaxing thermal constraints so as to enlarge the range of permitted solar aspect angles. Prototype detectors have been tested for radiation hardness and the measured leakage current appears to behave as predicted. However, the Study Team expressed concerns about transferring production to a new manufacturer and with different silicon wafer quality, while a demonstration of X-ray energy resolution after irradiation still has to be completed.

The Wide Field Monitor (WFM) team selected between two competing detector concepts the one with the highest Technology Readiness Level (TRL). It is also closer in design to that of the LAD. The WFM team requested a modest resource increase to allow a change of configuration that maximises the sky coverage in the anti-sun direction. This allows the most effective cooperation with ground based observatories.

The ESA study team started estimating the cost of the payload. The production cost per unit decreases with the number of units to be procured, but the exact scaling factor is uncertain at this stage. Nevertheless, first estimates suggest that the cost of the payload could be very large. One example is the cost of glass micro-channel plate collimators. Even assuming a drastic reduction in cost per unit area compared to e.g. the MIXS instrument on board Bepi-Colombo, scaling to a geometric area of 18 m^2 raises the cost to levels unsustainable for the consortium funding agencies.

A teleconference was held with the RXTE team to explore possible lessons learned in terms of mission design such as mission planning and spacecraft pointing autonomy. Based on RXTE experience, a straw man observing programme was compiled and used to verify the observing efficiency, lifetime and source statistics data. The plan was provided to industry for them to size the spacecraft attitude control system. Monitoring campaigns of known celestial targets and randomly occurring changes of their physical state have been considered, as well as Target of Opportunities. It was found that unless thermal stability constraints can be relaxed, it is not possible to monitor for sufficiently long all the Galactic binaries that are within a few degrees from the Galactic Centre. A key outcome of discussions with the RXTE team is the large effort which will be required to properly monitor the instrument background and the secular evolution of calibration observations. Such an intensive background monitoring has not yet been factored into the straw-man observing programme and it is uncertain whether it can fit into the 5% fraction of the observing time nominally reserved to calibration. Furthermore, the possibility of acquiring scientifically valid data during periods of thermal instability remains to be confirmed.

The provision of additional ground stations and low cost RF Burst Alert stations by other agencies is being investigated with the aim of minimising the response time to bursting sources. The need for continuous contact is confirmed such that one can measure and detect in near real time changes in the spectral emission states of celestial targets and react to rare burst events. Implications for the ground segment architecture and the functionalities required to support ToO observations are being investigated, as well as the repartition of tasks between ESAC and instrument team centres.

12.4 - STE-QUEST: Luigi Cacciapuoti

The STE-QUEST CDF (Concurrent Design Facility, at ESTEC) study report was finally delivered and published on the STE-QUEST website.

CNES has recently concluded a study on the adaptation to STE-QUEST of the PHARAO clock developed for the ACES project. The study results were provided to ESA and the STE-QUEST Science Study Team (SST) in January.

The clock and atom interferometer instruments went through their mid-term reviews, on 14 and 16 May respectively.

Work on the MOLO (Microwave-Optical Local Oscillator) optical cavity is progressing. The first results of the performance and radiation tests performed in Dusseldorf and Birmingham will be available in June.

Frequency combs based on diode-pumped solid state lasers are being investigated by CSEM. They are particularly interesting because of their tolerance to radiations.

A first design iteration of the optical link has been presented in the framework of the on-going ESA study on high-performance links for clock comparisons. Code phase measurements seem to be sufficient to meet the STE-QUEST requirements on the optical link. This would significantly simplify the link operation. Further analysis is needed to better assess the impact of atmospheric turbulence on the link noise.

Industry started designing and optimising the orbit. The 16 hour drifting orbit - already identified in the CDF study - appears to be the most promising as it offers the longest period of clock visibility at perigee as well as the longest periods where clocks located on different continents are visible to STE-QUEST for interrogation and comparison. Other options are being analysed. The Mission Baseline Selection Review (MBSR) of the TAS and Astrium studies will take place on 31 May and 11 June, respectively.

A first draft of the STE-QUEST ground segment concept has been prepared. The document identifies the main elements of the ground segment and describes the data flow between them as well as the main products of the mission.

A review of the STE-QUEST scientific requirements by industry did not identify major issues. The requirements will be critically assessed against the instruments design in the course of the clock and atom interferometer mid-term reviews.

The first results of numerical simulations aimed at verifying the clock performance for measuring gravitational redshifts and testing the Weak Equivalence Principle (WEP) were presented at the January meeting of the SST. These results confirm that STE-QUEST should be capable of achieving its stated scientific objectives.

The Science Study Team recently appointed a working group of theoreticians (L. Blanchet, C. Lammerzahl, S. Reynaud, P. Binetruy, D. Giulini, and S. Capozziello) charged with expanding the science case of STE-QUEST in the area of particle physics, cosmology and astrophysics. The group held its first meeting in Paris on April 19. Most models which aim at explaining Dark Energy invoke the existence of scalar fields which in turn imply a violation of the Einstein Equivalence Principle (EEP) at some level. The eventual discovery of the Higgs boson by the LHC would support the existence of non-universally coupled long-range scalar fields and therefore of

EEP violations. The working group stressed the importance of performing WEP tests on quantum objects. This is because, unlike macroscopic objects, the initial state and dynamics of quantum objects can be engineered in quite diverse and general ways such that the effects of the inertial and gravitational mass can be disentangled. These topics will be further elaborated in the STE-QUEST yellow book.

A special session on STE-QUEST is being organized at the next "From Quantum to Cosmos" conference which will take place in Cologne, from 9 to 12 October 2012. A dedicated workshop to present STE-QUEST to the scientific community will take place at ESTEC next January 22-23.

Two presentations on STE-QUEST were given at the "European Frequency & Time Forum (EFTF) 2012" conference. An oral presentation has also been accepted for the next COSPAR meeting.

13 - Satellites in orbit

13.1 - Herschel: Göran Pilbratt

Herschel continues to operate well and produces good science data. As of May 4, it had completed about 99% of the Key Programme (KP) Guaranteed Time (GT) and Open Time (OT) observations, 96% of the GT1 and 49% of the GT2, 80% of OT1 and 13% of OT2 priority 1 observations, as well as a number of priority 2 observations. Given the measured operational efficiency, all priority 1 observations will have been completed by the end of 2012, well before February 2013 when Herschel is expected to run out of helium.

The accuracy of the spacecraft pointing has been further improved. Following the previously reported refinement of the star tracker optical characterisation "focus" and "tilt" coefficients in June and September 2011 respectively, a 5-degree polynomial fit to all data was applied in February and the guide star catalogue was "cleaned" by removing about 2 % of its stars in March 2012. The pointing accuracy is now slightly better than 1 arcsec (1 sigma). Preparation has started for a global reprocessing of all previous observations with improved attitude data.

The Herschel Science Team (HST) held its 48th meeting at ESAC on 16-17 January 2012. The delivery of advanced data products by Key Programme (KP) holders, Herschel Science Archive evolution, pointing performance, as well as scoping and planning for the Post-Operations Phase (POP) were discussed. A series of teleconferences are taking place with each of the KP holders in turn to agree on delivery content and schedule of enhanced science products.

At its 4th meeting in ESAC on 15-16 December, the Herschel Users' Group (HUG), like the HST before, emphasized the importance of the POP and expressed worries about resource limitations. HUG minutes and recommendations can be consulted at http://herschel.esac.esa.int/HUG.shtml.

On the initiative of the Project Scientist and together with the Mission Scientists, the entire set of approved observations is currently being assessed for possible "holes", i.e. observations which are currently not foreseen but whose scientific importance is such that "must" be carried-out prior to helium exhaustion. If any such observations exist, they will be carried-out under Director's Discretionary Time.

A number of web-stories and image releases have been posted on the Space Science Portal and the Science & Technology web sites at http://herschel.esac.esa.int/Press_Releases.shtml.Here are two examples:

- Fomalhaut, one of the most studied main-sequence stars with a so-called infrared excess, was imaged by Herschel (Acke et al. 2012). Covering the range from 70 to 500 μm, the five

images resolve the system, the most prominent feature being the main belt whose internal radius is 130 AU. Dynamical and radiation transfer modelling reveals a very active system of "fluffy" grain aggregates, which needs to be replenished by the continuous grinding down of 2000 1-km-sized comets every day

- Combining Herschel and Chandra observations of $1 < z < 3$ galaxies in the Chandra Deep Field North, Page et al. (2012, Nature 485, 213) have shown that vigorous star formation is quenched in galaxies harbouring AGN whose X-ray luminosity exceeds 10^{44} ergs/s. Using Herschel/SPIRE luminosity as a proxy for the star formation rate and Chandra X-ray luminosity as a measure of AGN activity, they find a correlation between the two quantities. However, the correlation breaks down at high luminosity in the sense that the highest X-ray fluxes severely under-predict the mm flux. Quenching of star formation in the host galaxy of powerful AGN is a key prediction of the so-called feedback models in which AGN driven outflows wipe-out the host galaxy of its interstellar gas reservoir in a cosmically short episode.

Multi-wavelength images that combine Herschel and XMM-Newton data among others have also been published of M16 (the "Eagle Nebula") and Cen-A, the closest giant elliptical galaxy that harbours a radio-loud AGN.

At the time of writing, 418 articles based on Herschel observations have been published in the refereed literature since launch, of which 94 are far from 2012. The publications list is available at http://herschel.esac.esa.int/ScientificPublications.shtml .

13.2 - Planck: Jan Tauber

The amount of on-board helium gradually reduced to a level where it could no longer maintain the operating temperature of the HFI bolometers. By 16 January 2012, exactly as predicted, the temperature had risen to a level of 0.13 K and the acquired data were no longer useable. This marked the end of the first Planck extension and the start of the LFI-only extension phase.

In total, five complete and uninterrupted all-sky surveys have been carried-out with the full payload complement, over twice the initial baseline. The LFI continues to survey the sky while HFI remains in operation since it is needed to operate the 4 K cooler and maintain the temperature of the LFI's reference loads.

Operations continue to be smooth, with extremely stable conditions. Planck/LFI is now close to completing its sixth all-sky survey. During the first months of its LFI-only extension phase, Planck carried out deep observations of Jupiter and the Crab.

The approved LFI-only extension phase will last one year, i.e. until mid-January of 2013. The useful lifetime of the LFI is driven by the performance of its "sorption cooler". So far, the unit which is currently in operation has performed much better than originally expected. It is therefore likely that the LFI will continue to gather useful data at least until the end of the approved period. It is quite possible that the sorption cooler may continue to operate even beyond January 2013. To prepare for this eventuality, a proposal to extend Planck/LFI operations is being drafted and will be submitted to ESA's advisory structure in the coming months.

The first set of Planck data products is due to be delivered to ESA in December 2012, for ingestion into the Planck Legacy Archive and release to the community in January 2013. For practical

reasons (drafting of science papers, preparation of the associated documentation, the logistics of data formatting and ingestion ...) these products must be in their quasi-final form already by mid-2012. A delta-review took place in April to assess the progress made by the Data Processing Centres (DPC) since the "mid-course review" in July 2011. The review Board did not identify major short comings or deficiencies that would prevent the DPC from reaching that goal but stressed that the schedule was quite tight. The Board report is in the process of being finalised.

The NASA Senior Review of Operating Astrophysics missions met recently. The nine missions considered included Planck and XMM-Newton. The committee is charged to evaluate the anticipated science productivity of each mission for the next four years, but focussing on 2013 and 2014. Both ESA missions were ranked extremely highly. For Planck, the Senior Review recommended continuing with US support to the current LFI-only extension as well as providing support to the US Planck Data Centre through to the planned second cosmology data release in early 2014. Further support to a third data release is not excluded.

In December 2011, *Astronomy & Astrophysics* published a special feature dedicated to early scientific results from the Planck mission. It contained 26 scientific papers, describing the mission and payload, the Early Release Compact Source Catalogue (ERCSC) published in January 2012, an initial scientific analysis of the ERCSC and selected results on diffuse foreground emissions.

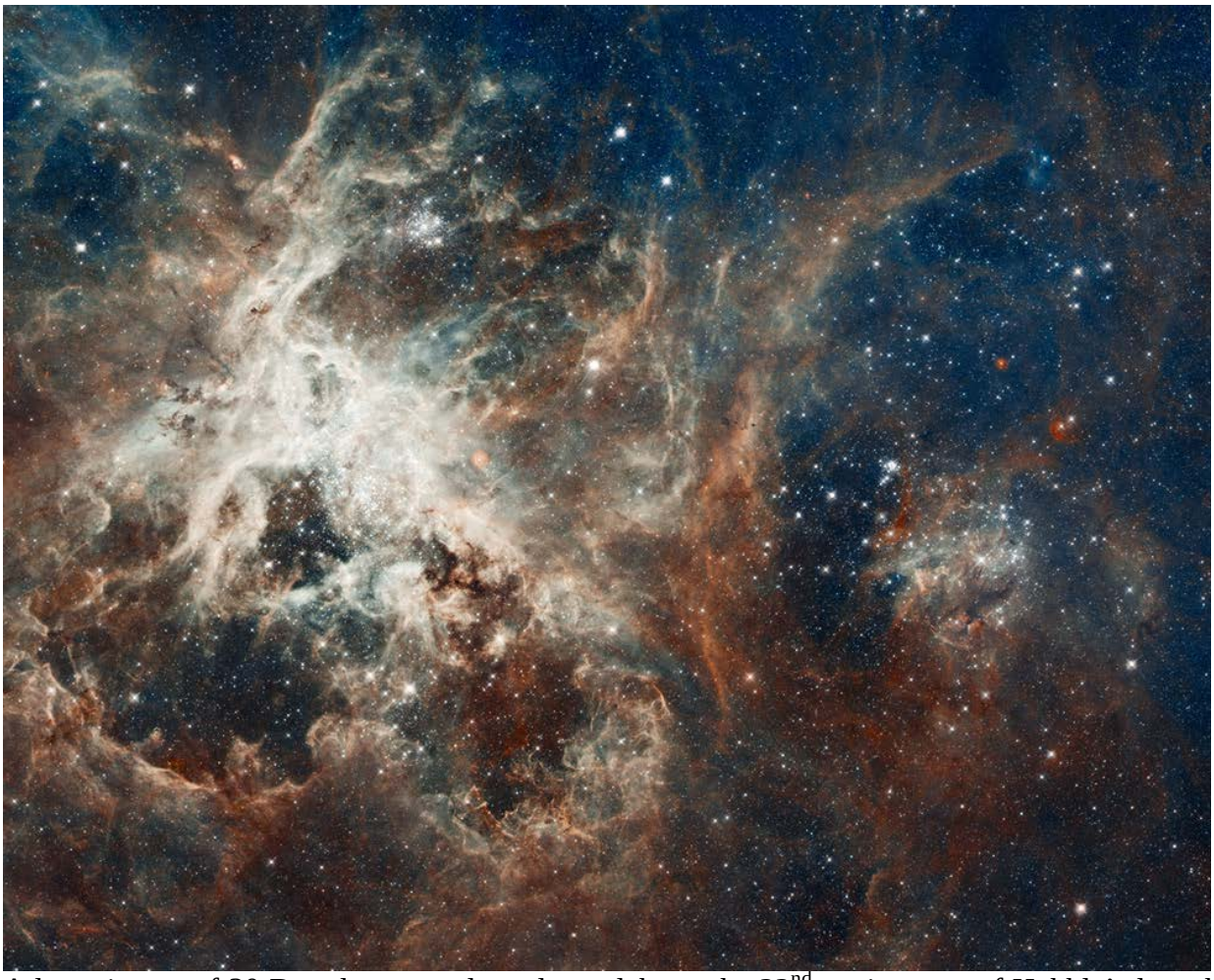
A conference on "*Astrophysics from the radio to the sub-millimetre"*, organised by the Planck Collaboration and gathering nearly 200 scientists took place in Bologna between 13 and 17 February 2012. During this conference, 14 papers were presented describing new scientific results from Planck. Among these, of note (and highlighted in ESA outreach articles) were the extraction of an all-sky CO map by Planck, and an analysis of the "galactic haze", a hard synchrotron emission localized around the Galactic Centre and linked to the "bubbles" observed by Fermi. For more details, see http://www.esa.int/SPECIALS/Planck/index.html

13.3 - HST: Antonella Nota

The HST mission proceeds nominally. Observatory efficiency remains at or above 50% and all operating subsystems continue to function well. Hubble has passed another milestone with the publication of its 10,000th refereed scientific paper. The lead author of the paper is Zach Cano of Liverpool John Moores University in the United Kingdom. He reports on the identification of the faintest ever supernova to be associated with a long-duration gamma ray burst.

The Space Telescope User's Committee (STUC) met at STScI on April 12-13. The STUC meets at STScI twice a year to advise on the Hubble scientific program. ESA appointed representatives are Nial Tanvir (UK), Giampaolo Piotto (IT) and Annette Ferguson (UK).

The Time Allocation Committee (TAC) will meet at STScI on May 21-25 to assess the proposals submitted in response to Cycle 20 AO. Out of 1090 proposals received, 214 have a European PI (~20%). From the 100+ participants to the proposal selection process, 21 are Europeans scientists who are involved either as TAC members, panel chairs or panel members. The programme recommended by the TAC will be published at the beginning of June.



A large image of 30 Doradus was released to celebrate the 22nd anniversary of Hubble's launch. The image is one of the largest mosaics ever assembled from Hubble data and consists of observations taken with Wide Field Camera 3 and Advanced Camera for Surveys, combined with observations from the European Southern Observatory's MPG/ESO 2.2-metre telescope that trace the location of hydrogen and oxygen emission. No known star-forming region in our galaxy is as large or as prolific as 30 Doradus. This image shows star clusters of various ages, from about 2 to 25 million years, and reveals the different stages of star formation, from embryonic stars a few thousand years old still wrapped in dark cocoons of dust and gas to behemoths that die in supernova explosions.

Astronomers using the Hubble Space Telescope have found a cluster of young stars surrounding a mid-sized black hole called HLX-1. The discovery suggests that the black hole formed in the core of a now-disintegrated dwarf galaxy. The findings have important implications for understanding the formation and evolution of supermassive black holes and galaxies. While it is known how massive stars collapse to form small black holes of a few solar mass, it is not clear how supermassive black holes form in the cores of galaxies. One idea is that supermassive black holes may build up through the merger of small and mid-sized black holes, a view supported by this new study. Sean Farrell of the Sydney Institute for Astronomy in Australia and the University of Leicester, UK, discovered an intermediate mass black hole in 2009 using X-ray data from XMM-Newton. Known as HLX-1 (Hyper-Luminous X-ray source 1), this black hole has a mass of

~ 20,000 M_O and lies towards the edge of the galaxy ESO 243-49. Farrell's team studied HLX-1 in ultraviolet, visible and infrared light using Hubble, and simultaneously in X-rays with the Swift satellite. HLX-1 is too far for HST to resolve individual stars. However, Hubble's images show an excess of red light, which cannot be accounted for by emissions from the accretion disc alone. This light is evidence for a cluster of hot young stars surrounding the black hole since its luminosity and energy distribution resembles that from star clusters in nearby galaxies. The existence of a young star cluster around the black hole in turn gives clues about where the intermediate mass black hole may have come from, and why it lies in its current location in ESO 243-49. It indicates that the intermediate-mass black hole may have originated as the central black hole in a very low-mass dwarf galaxy. The dwarf galaxy, together with its central black hole, was then accreted by the more massive galaxy ESO 243-49. The future of the black hole is uncertain at this stage. It depends on its trajectory, which is currently unknown. It is possible that the black hole may spiral into the centre of ESO 243-49 and merge with the super-massive black hole there. Alternatively, the black hole could settle into a stable orbit around the galaxy. Either way, it's likely to fade away in X-rays as it depletes its supply of gas (Farrell, S. et al. 2012, ApJ 747L, 13F).

13.4 - XMM-Newton: Norbert Schartel

The spacecraft and payload continue to operate nominally. The final presentation of the outcome of Phase I of the Astrium study on the use of the fourth reaction wheel took place on 17 April 2012. The consortium (Astrium GmbH, Astrium UK, RHEA and SciSys) have re-established an AOCS simulation environment, determined the necessary algorithms and on-board software changes and verified that XMM-Newton has sufficient resources to operate with four wheels on simultaneously (power, on-board memory, CPU processing power…). No showstoppers have been identified. In addition, and with the concerns about reaction wheel "caging" reported previously, the proposed change will allow more benign reaction wheel operations which should help counter any degradation in performance. Astrium GmbH indicated that implementation of 4-wheel control system will take one year. A formal decision will be taken by the Mission Extension Operations Review Board at the end of June

Following the successful transfer of the data processing system from the XMM-Newton Survey Science Centre in Leicester to ESAC, all pipeline operations are now carried-out by the Science Operations Centre (SOC) since March 1.

The NASA Senior Review of Operating Astrophysics missions met recently. The nine missions considered included Planck and XMM-Newton. The committee is charged to evaluate the anticipated science productivity of each mission for the next four years, but focussing on 2013 and 2014. Both ESA missions were ranked quite highly. For XMM-Newton, the Senior Review recommended an extension through 2016 with NASA funding the Guest Observer Facility (GOF) at the current level and a tripling of the Guest Investigator funding from 1 M$ to 3 M$ per year.

Over 120 scientists registered to the XMM-Newton workshop, "Galaxy Clusters as Giant Cosmic Laboratories" which took place at ESAC from 21 to 23 May. The science programme featured 60 contributed talks and 20 poster presentations.

The following scientific workshop is planned for the period 22-24 May 2013 with the title "The fast and the furious: energetic phenomena in isolated neutron stars, pulsar wind nebulae and supernova remnants". Dr. S. Mereghetti (Milano) chairs the scientific organizing committee.

The 4-year term of C. Cesarsky as chairperson of the Observing Time Allocation Committee (OTAC) expires in December 2012. M. Salvati (Arcetri Observatory) will chair the OTAC from 2013 (AO-13) onwards.

Two independent papers by A. Kaur et al. (2012, A&A 538, A49) and by M.J. Middleton et al. (2012, MNRAS, 420, 2969) quasi simultaneously reported about XMM-Newton observations of the first ultra-luminous X-ray transient in M 31. The new, transient ultra-luminous X-ray source (ULX) was discovered by Chandra in M31 with a luminosity at ~5×10^{39} erg s^{-1}. Five subsequent XMM-Newton observations show a steady decline in X-ray luminosity over 1.5 months, from 1.8 $\times 10^{39}$ to 0.6 $\times 10^{39}$ erg s^{-1}, yielding an e-folding time-scale of ~40 days. These data strongly support a model whereby matter is accreted at the Eddington limit onto a stellar mass black hole in a Low Mass X-ray Binary system (LMXB). This is the first convincing identification of ULX with a "standard" X-ray binary system.

The *Astrophysical Journal* published a paper (2012, ApJ 747, 32) by G. E. Bulbul et al. about XMM-Newton high resolution spectroscopy of the cooling flow cluster A3112. Comparison of the Fe XVII and Fe XVIII line fluxes reveal no measurable amount of cool (T < 1 keV) gas within the central 52 kpc core of the cluster. The spectra also yield an upper limit of 206 km/s to turbulent velocities which implies that turbulence contributes at most 6 % of the gas energy budget in the core of A3112. This result is consistent with those obtained earlier by Sanders and Fabian and indicates that the dissipation of turbulence is insufficient to prevent run-away cooling of the intra-cluster gas.

As of April 30, 3043 articles based on XMM-Newton data have appeared in the refereed literature, of which 89 are from 2012.

13.5 - INTEGRAL: Christopher Winkler

The spacecraft, payload and ground segment continue to perform nominally. Scientific observations proceed as per the AO-9 plan. The IBIS Data Processing Electronics (DPE) crashed twice in January and late February, most likely due to communication problems. IBIS was subsequently deactivated and re-activated on March 30 and no further problems were observed. Because of strong solar flares, the payload was put into safe mode twice, from 13 to 15 January and from 7 to 13 March.

During SPI annealing #18 in Nov-Dec 2011, it was noted that the leakage current of the Ge detectors #8 and #11 was higher than usual and that the preamplifier's DC output voltages of both detectors were about 0.3 V higher than that of the other detectors. Subsequent analysis indicated that a destructive flash of the high voltage (HV) could have caused the change of the preamplifier's DC output voltage. For memory, a HV flash had been identified as the likely cause of the last Ge detector failure in May 2010. On April 15, as a preventive measure to guard against further failures, the operating voltage of all Ge detectors was permanently reduced from 3 kV to 2.5 kV. This results in a 5 to 6% degradation of the energy resolution above 1 MeV, leading to a 3% decrease in line sensitivity. No performance degradation is measured at lower energies.

Lorraine Hanlon (IRL), Tony Bird (UK) and Dieter Hartmann (USA) were appointed as external

scientists in the INTEGRAL Users Group, for a four-year term starting in July 2012.

By the deadline of April 20, 59 observing proposals had been received in response to AO-10 with an over-subscription in time by a factor 3.3. The corresponding numbers for AO-9 were 49 and 2.9, respectively. These include 31 ToO proposals and 18 Key Programme (KP) proposals (T_{exp} > 1 Ms), where 8 KPs are multi-year programmes. The TAC will meet in early June to peer review the proposals and to recommend the AO-10 observing programme. The AO-10 cycle of observations will start on 1st of January 2013.

S. Tsygankov et al (MNRAS in press, arXiv:1201.0616) report the discovery of a cyclotron absorption line in the persistent Be/X-ray pulsar RX J0440.9+4431. Before 2010, this system had been catalogued as a persistent low-luminosity binary. Beside the Be star, it harbours a slowly rotating neutron star with a pulse period of 202.5 s. The first evidence of an X-ray outburst was observed in March 2010 by the MAXI all-sky monitor. A second outburst in September was recorded by INTEGRAL while a third one in January 2012 was detected by Swift. Taking into account that the peak luminosities of all three outbursts were relatively low (Type I outbursts) and that they were roughly equally spaced in time, the orbital period of RX J0440.9+4431 was estimated to be ~155 days. This value is in good agreement with the 150 days period derived from the Corbet P_{spin} - P_{orbit} correlation. Analysis of INTEGRAL data reveal a cyclotron resonant scattering line at ~32 keV, which yields an estimate of the neutron star magnetic field strength of 3.2×10^{12} G. RX J0440.9+4431 is only the second persistent Be/X-Ray pulsar binary system (with X Persei) for which the strength of the magnetic field and the orbital period could be determined.

A web story describing INTEGRAL and RXTE observations of the magnetar 1E 1547.0-5408 was published on the SciTech portal on 12 April, in coordination with a SRON press release.

The second circular announcing the 9th INTEGRAL Workshop "An INTEGRAL view of the high-energy sky (the first 10 years)" was issued at the end of April. The workshop will take place on 15-19 October 2012 in Paris to celebrate the 10th anniversary of the launch. The deadline for abstracts is June 15.

Three web stories were published on the ESA Science & Technology web portal during the reporting period:

- "*INTEGRAL deciphers diffuse signature of cosmic-ray electrons*", 21 Dec 2011.
- *"INTEGRAL reveals new facets of the Vela pulsar wind nebula"*, 25 January 2012
- *"Massive glitch moves magnetar modelling forward"*, 12 April 2012.

By the end of March, the total number of refereed publications since launch was 673 of which 14 are from 2012.

13.6 - SUZAKU (ASTRO-E2): Arvind Parmar

The Japanese-US X-ray astronomy mission Suzaku was launched in July 2005. Following the early failure of its prime instrument, the observatory is performing astronomical observations with the remaining X-ray CCD cameras and hard X-ray detector. Scientists from institutes located in the ESA Member States appear as authors of 150 refereed papers that make direct use of data from the mission. The data for many of these papers have been obtained through annual European Suzaku Announcements of Opportunity.

The seventh such European Announcement (EAO-7) closed on 10 November 2011. The European proposals were ranked by the ESA appointed TAC and the results forwarded to JAXA for merging with the Japanese and US proposal selections. The approved target list for the European AO-7 observations to be performed between April 2012 and March 2013 is to be found under http://www.rssd.esa.int/suzaku. There are eight European proposals in Priorities A and B (20 pointings) for a total of 760 ks and eight Priority C targets (fillers) for a total of 660 ks. As in previous AOs, the European targets will account for around 8% of the total open observing time.

13.7 - CoRoT: Malcolm Fridlund

After more than 1950 days in orbit, CoRoT continues to operate nominally though without DPU#1 which failed in 2009.

On March 29, CoRoT completed a 77 days observation toward the galactic anti-centre (LRa06 run). The cumulative exposure time on this field now reaches 217 days in total. This is the field which contains CoRoT-7b, the first terrestrial planet for which both the radius and the mass could be measured. The planet was also detected again in new radial velocity measurements in a parallel investigation by a separate team that only partially overlaps with CoRoT co-investigators. The star is presumably approaching the minimum of its cycle since its stellar activity has decreased by about a factor 10 since the previous observation. This will make it easier to confirm or exclude the existence of the CoRoT-7c and CoRoT-7d super-Earths candidates suggested by earlier data.

Between 30 March and 2 April, CoRoT acquired stray-light data which are necessary for preparing the extension of the mission. Indeed, it is planned to enlarge the radius of the field-of-view accessible to observation from 10 to 15 degrees, which in turn depends on the stray-light rejection efficiency of the baffling system. CoRoT was subsequently re-pointed toward the galactic centre (LRc09 field) for an 84 days observation that will end on July 5.

The ground-based follow-up program is progressing slowly but steadily. The science team estimates that it has been completed for 3 “runs” out of the 23 carried-out so far: LRc01, SRc02 and LRc03. Detailed scientific interpretation is in progress on confirmed planets up to CoRoT-29b.

The total number of refereed scientific articles based on CoRoT data published to date is 430, out of which 29 are from 2012. These articles have attracted 6551 citations so far. In total, 25 TB of data have been retrieved from the CoRoT public archive.

The lifetime of CoRoT is not significantly constrained by consumables and performance degradations have been negligible so far. A proposal for a 3 years extension of operations beyond April 2013 was therefore submitted to CNES on February 6. The programme can be consulted at http://smsc.cnes.fr/COROT/PDF/CoRoT_III_programme.pdf. A formal decision is expected in June.

14 - Projects under development (cont.)

14.1 - LISA Pathfinder: Paul McNamara

The Science Runs Closed Loop Test (CLT) campaign of the LISA Pathfinder (LPF) flight spacecraft was recently completed at the Industrial Prime Contractor’s premises. These tests exercised all flight units in a closed loop configuration, with electrical stimuli to simulate the free-floating test masses, the micro-Newton thrusters, and overall spacecraft dynamics. The tests

successfully validated 6 out of the 12 scientific experiments currently planned. The remaining 6 experiments will be validated on the Real-time Test-Bed (RTB) hardware-in-the-loop simulator.

Qualification Review, part 1 (QR#1) is currently in progress. The QR goal is to verify that all flight and spare units have been properly tested and qualified during preceding environmental and functional tests. Since some sub-systems are not available yet, the review has been split in two, with the second part of the review scheduled after the hibernation period. The QR#1 Board meeting is scheduled on June 22. This will mark the formal start of the hibernation for the industrial teams.

Significant progress has been achieved with the FEEP (Field Emission Electric Propulsion) micro-propulsion system. The first successful test of the thruster-head has recently been completed, demonstrating a total impulse of 1084 Ns accumulated over ~3000 hours of continuous operation. This greatly exceeds the LISA Pathfinder requirement of 600 Ns. Testing of a second thruster head started on May 8 and will last 3 months. If successful, qualification of the FEEP thruster units will resume. Should this fail, the cold gas thruster technology successfully developed for Gaia is available as a back-up. Switching to cold gas would require some modifications to the spacecraft which, though relatively minor, would nevertheless delay the programme by several months. The final selection of the thruster technology will be made during the fall of 2012.

Work on the LISA Technology Package (LTP) is progressing according to schedule. The main efforts are focussed on the inertial sensor head. The flight models of the test masses have now been machined and polished, and will be gold-coated in early June. The electrode housings flight units are scheduled for delivery in the same timeframe. The caging mechanism launch locks remain the project most critical items and are currently delaying integration of the payload. Their delivery is scheduled to start in October of this year. If successful, the two inertial sensor units will then be integrated leading to their delivery in April & June 2013 respectively.

Concerning the optical metrology system, all flight units had already been validated in the course of the so-called On-Station Thermal Test last year with the exception of the optical bench and photodiodes which were only tested as flight spares. The decision was recently taken to up-qualify the optical bench and detectors to full flight status. The optical bench was therefore removed from the spacecraft and is currently being subjected to thermal and vibration acceptance tests that will continue for the next three months.

Development of the Science Ground Segment is proceeding as planned. Representatives of the Science Working Team and the STOC (Science & Technology Operation Centre, ESA) played a prominent role in the above mentioned Closed Loop Tests campaign, by providing near-real time data-analysis support to industry. Not only did this alleviate the burden on industrial teams and greatly sped-up the execution of the test, but it also provided hands-on experience to the SWT members in an operational-like environment.

Several training sessions of the LISA Pathfinder scientific community took place over the reporting period: the first of a series of workshops entitled the “LPF School” was held in February at ESTEC. The purpose the school is to give to the scientific community (and project engineers) a one day system-level tutorial on LISA Pathfinder. It focused mainly on the hardware and the drag-free control system, but also included a short tutorial on data analysis. The LPF School was attended by 40 participants. It was followed by a Data Analysis hands-on training session. This

built on the information provided during the school, but went more into the details of the analysis of simulated LPF data and modelling of the system. The next training session will take place at ESAC in June. Building on the previous two training sessions, it will consist of a complete end-to-end operational simulation lasting three days, from the planning of the experiments, to real-time execution, data analysis and contingency re-planning as required. The goal of this session is to give the community some first-hand experience of a realistic operational scenario. All these sessions are organised by the STOC scientists with help from the SWT.

A somewhat expanded Science Working Team is currently investigating the possibility of using LISA Pathfinder to test alternative theories of gravity. Several of these theories, e.g. MOND or TeVeS, predict deviations from Newtonian gravity when the background gravitational acceleration falls below a given threshold ($\sim 10^{-10}$ ms^{-2}). Such conditions are encountered at the so-called *saddle points* where the gravitational field of, e.g. the earth and the sun almost exactly cancel each other. Preliminary estimates show that the LTP instrument has enough sensitivity allows to measure deviations from Newtonian theory predicted by MOND or TeVeS. Further investigations, focussing primarily on the exact determination of the required orbit and data analysis effort, are in progress.

14.2 - JWST: Pierre Ferruit

Both the House and Senate spending bills for the 2013 fiscal year include funding for the mission at the level requested by the White House (US$ 628 million) and the JWST project for a 2018 launch. At NASA JWST project level, the emphasis continues to be on the delivery of the instruments, their integration into the Integrated Science Instrument Module (ISIM) and the preparation of the first ISIM-level cryogenic test campaign planned to start in March 2013.

The MIRI optical system (OS) acceptance review and pre-shipment review board met on May 3. It formally accepted the MIRI OS for integration into the ISIM and approved its shipping to the NASA Goddard Space Flight Centre. There are two remaining open points, both related to the focal-plane system developed by JPL. These will be addressed in parallel using a high-fidelity test bed available in the US to investigate the anomalies and to validate potential hardware modifications, should these become necessary. The MIRI OS will be the first of the four JWST instruments to be delivered to NASA and integrated in the ISIM structure.

Reintegration of NIRSpec on the FM2 optical bench has started and the first optical elements have been successfully installed and aligned. Once the integration is completed, the NIRSpec flight model will be subjected to a short cryogenic test cycle followed by vibration and acoustic tests. The micro-shutter assembly (MSA) flight model (FM) will then be installed after which the main NIRSpec cryogenic test campaign will start sometime toward the end of the year. Delivery to NASA is scheduled for spring 2013.

In parallel to the integration of the flight model, the NIRSpec engineering test unit (ETU) is being prepared for re-delivery to NASA. It will be integrated in the ISIM and, together with the flight models of the other instruments, it will undergo the first cryogenic cycle during the spring of 2013. It will later be exchanged with the NIRSpec FM when the later becomes available.

Good progress has been achieved toward the replacement of the near-infrared detectors for all 3 instruments. NASA and Teledyne recently held a successful manufacturing readiness review of

the new detectors. Exchange of the detectors is currently planned in 2014. In addition, a successful review of a detector noise mitigation method paved the way for its implementation as an additional readout mode of the NIRSpec detectors.

14.3 - ASTRO-H: David Lumb

The first phase of the spacecraft system Critical Design Review (CDR) was successfully completed and the review board recommended continuing with the development. Some items could not be endorsed on the basis of design documentation alone. Extensive thermal and mechanical test campaigns are therefore under way to establish confidence in the design of the fixed and extendible components of the optical bench and to verify that vibrations from the cooling system are at an acceptable level. The instruments schedule is on the critical path of the ASTRO-H projects, even when considering the launch slip to August 2014 required to accommodate the aftermath of the 2011 earthquake in Japan.

Breadboard tests demonstrated that the telescope angular resolution and effective area, and the spectral resolution of the cryogenic spectrometer will all exceed requirements with comfortable margins.

Of the European institute-provided hardware, the Spectrometer Filter Wheel successfully passed its CDR in December. after TTM/MTM tests, all instrument sub-systems will be re-visited as part of the system-level CDR phase 2 to confirm that their design remains fully valid under updated mechanical and thermal conditions.

The ESA-provided hardware, which is procured under a contract with Carlo Gavazzi Space, has progressed well. The procurement of Bismuth-Germanate (BGO) crystals for anti-coincidence detectors, from a Russian source via the Dutch company SCIONIX, is almost completed. Samples of BGO are currently being tested for radiation damage using the ESTEC ^{60}Co source. The High Voltage Power Supplies procured through the company SITAEL suffer from a potting failure in one of the commercial components of the Engineering Model (EM). The qualification campaign will continue after re-potting on the EQM. There was also an electrical failure during the tests which was subsequently attributed to an operational amplifier. Unfortunately this component has now been put on the ITAR list and is no longer available. The Non-conformance Review Board (NRB) concluded that a different component will have to be used. Candidates are currently being investigated by SITAEL. Procurement and testing of Liquid Heat Pipes by IberEspacio is proceeding smoothly. Radiation testing of CdTe detectors at CEA is about to start.

The management of ESA Calls for observing proposals will be based on the system developed at ESAC for Suzaku. Any additional effort in User Documentation, Software Testing and Calibration Analysis will be scoped to fit the available resources. The Invitation to Tender (ITT) for user support activities at ISDC was delayed which has hampered attempts to start software testing activities. An outline of task distributions has been discussed between ESAC, JAXA and NASA GSFC. The ASTRO-H software architecture can only support data distribution from one single mission archive. Each data set is automatically encrypted by ISAS prior to its release to each individual observer.

At its last meeting, the Science Team agreed guidelines for the execution of the Performance

Validation (PV) phase observations and for the participation of the team to the data analysis effort. Calibration requirements and in-orbit target selections were reviewed and the importance of cross-calibrating ASTRO-H with XMM-Newton and Integral was underlined. The ASTRO-H Science Team started collecting inputs for the compilation of a PV observation plan, with 109 titles received so far, most of them for the high resolution cryogenic spectrometer instrument.

The ASTRO-H office holds annual Summer Schools in Japan for post-grad students and post-docs. They focus on science topics relevant to ASTRO-H. The office made a plea for European (and US) participation in order to broaden the school profile and encourage international collaborations.