

## **Project and Study Scientist Reports for AWG # 143**

16-05-2011

Report compiled, using inputs from Study and Project Scientists by Jean Clavel, head Astrophysics & Fundamental Physics Missions Division.

### **4 Status report of missions in definition phase**

#### **4.1 Euclid: René Laureijs**

Following their response to the Announcement of Opportunity, the Euclid Mission Consortium (EMC) was formally selected by the SPC in February. The consortium consists of about 400 scientists coming from nine European countries and has a majority representation in the Euclid Science Team. The consortium will deliver the two payload instruments - the visual imager (VIS) and the near-infrared photometer and spectrometer (NISP) - and important components of the Euclid science ground segment. Upon recommendation of the AWG, I. Baldry (Liverpool) was appointed as Independent Legacy Scientist member of the Euclid Science Team.

On February 14, NASA officially notified ESA that they can no longer be partner in Euclid. These had two immediate consequences. First, the NIR detectors and proximity electronics – formerly a US deliverable – will now be procured by ESA, the consortium remaining responsible for the remainder of the detector system and for their integration into NISP. Second, the two US NASA appointed members of the science team had to be replaced by members from the Consortium. To reflect these modifications, the Euclid Science Management Plan updated and circulated to the AWG on May 11.

On the 25<sup>th</sup> of February, the EMC Board appointed Yannick Mellier (IAP, France) as the new consortium Lead. CNES took-over from ASI the management of the near infrared photometer and spectrometer (NISP) instrument and appointed a new NISP project manager.

In March, ESA conducted a Mid-Term Review (MTR) of the EMC status and of the progress achieved in implementing the recommendations issued by the consortium proposal evaluation Committee last December. The MTR Board concluded that the EMC had made good progress in streamlining the consortium management structure, in consolidating the NISP instrument design and in defining the architecture of the EMC contribution to the science ground segment. Nevertheless, the Board also expressed concerns about the absence of an end-to-end scientific performance calculator as an essential tool to support the Euclid mission. In response to the MTR Board report, the EMC, with the support of ESA, organised a workshop at ESTEC from 2 to 6 May to consolidate Euclid end-to-end performance calculations. The workshop was quite successful. As a result, scientific requirements have been clarified, consolidated, properly justified and hopefully brought in line with the current mission design (TBC).

The Phase-A studies carried out by the EMC and the two industrial contractors are now nearing completion. The studies indicate that requirements on image quality and survey area are the main drivers of the mission. A Preliminary Requirements Review (PRR) is being held from 23 May to 14 June 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 (3) the technical feasibility of the mission,

through appropriate definition and modelling. The PRR marks the formal completion of Phase-A studies. The Euclid Science Team will summarise the outcome in the Phase-A Study report, also known as “Red Book”, which will be circulated to the ESA advisory structure on July 15. In parallel, ESA has released a solicitation for a proposal by the Euclid Mission Consortium defining EMC activities in support of the Euclid implementation and operations phases. The EMC proposal is due on the 12<sup>th</sup> of July.

#### **4.2 PLATO: Malcolm Fridlund**

All members of the PLATO Science Team (PST) have now been appointed: C. Catala (Paris Observatory), D. Pollaco (Queens U, Belfast), H. Rauer (DLR, Berlin), R. Raggazoni (Padova Observatory), J. Miguel Mas Hesse (CSIC-INTA, Madrid), S. Udry (Observatory of Geneva) and the Independent Legacy Scientists G. Micela (Observatory of Palermo). 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 29 of April with a due date of 12 July.

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 16 May and 14 June. The PRR objectives are the same as for Euclid (see above).

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 the 11<sup>th</sup> of May.

### **9 Status Report on assessment study activities**

All three Large (L) Cosmic Vision missions were planned to be implemented in roughly equal partnership with NASA and in the case of IXO, with JAXA as well. Publication of the astrophysics US decadal surveys report in September 2010 followed by the planetary science report in March 2011 shows that none of the three missions ranks high in the priority list of the American scientific community. Given the tight US budgetary situation, this means that NASA can no longer contribute to any of the 3 L projects at the level previously envisaged. In March, ESA was thus formally notified that NASA abandoned its participation to IXO, LISA and Laplace/EJSM.

None of the three missions is feasible by ESA alone within the L-cost envelope of 650 M€ (2008 e.c.). In consultation with the SPC chair, the plan to down-select two L missions in June for a definition study was therefore abandoned. On the 14<sup>th</sup> of March, the SPC was informed of a new approach whereby descoped Europe-only versions of IXO, LISA and EJSM/Laplace would undergo short feasibility studies leading to a possible down-selection in February 2012. Study reports (akin to “Yellow Books”) would be made available to the working groups and SSAC in November 2011 for their evaluation and recommendations to the executive. The cost ceiling of a Europe-only L mission has been tentatively increased to 850 M€ (ESA cost only, 2010 e.c.) and the launch date moved to 2022. Participation of a partner agency is possible provided it remains below 20% of the total mission cost. Note that this plan is still provisional and requires SPC approval.

The science study teams of the defunct L missions were disbanded and new teams were appointed. To keep the door open for a possible future collaboration, NASA appointed one US observer on each of the three teams. The provisional name of the X-ray mission is Athena while the successor of LISA has been re-baptised New Gravitational-waves Observatory (NGO) for lack of a better name.

## **9.1 SPICA: Kate Isaak**

The two parallel industrial studies of the SPICA Telescope Assembly (STA) are proceeding nominally. The optical design has been completed and industry is now working on thermal, mechanical, structural and programmatic aspects. A detailed analysis of stray-light contamination is also in progress, an issue particularly relevant at long-wavelengths and thus to SAFARI. Both industrial designs meet the stringent requirements on wave front error placed on the STA by the coronagraph. The telescope cannot deliver diffraction-limited performance at 5 $\mu$ m at the field angle of the MIR instrument (10'). However the requirement can be met through corrective optics at instrument level.

A SPICA project-level review of the Focal Plane Instruments (FPI) was initiated by JAXA in mid-May, with participation of all partners in the project. The final Board report is expected in mid-September, including a recommendation on the selection of the instrument suite. The science panel include members of the E3SAT. Prof Rob Ivison (UK) also participates to the panel deliberations as expert on MIR and NIR cosmological surveys. Two members of the AWG (Dieter Lutz and Nabila Aghanim) will follow the review as observers.

The SAFARI consortium held its biannual consortium meeting in Utrecht on 8-10 March. Significant progress has been achieved with the TES detector performance, the measured sensitivities at pixels level being now within a factor 1.5 of the mission goal. Thermal, mechanical and power constraints necessitate a reduction in the number of pixels of the short-wavelength (34 - 60 $\mu$ m) array. The impact this may have on the science performance of the instrument is currently under evaluation.

The SAFARI Science Verification Review board report was issued on March 2. Among other things, the report recommends to review and update the science requirements, define the in-flight calibration strategy, review the detector chain, consolidate the resource budgets and instrument interfaces, and to perform a detailed assessment of the optics. These recommendations are currently being worked upon by the SAFARI consortium and will be implemented by the time of the next consortium meeting in September.

## **9.2 New X-Ray Observatory (Athena): David Lumb**

On February 3, the chair of the Science Team, K. Nandra (MPE Garching) and the ESA Study Manager, N. Rando, presented the results of the IXO assessment studies at the L-class mission public presentation event in Paris. An IXO science workshop was subsequently held at CNR HQ in Rome in March, but this was over-shadowed by the announcement the same week to redirect the L-class missions toward an ESA-only implementation.

Since then, the ESA study team has been actively looking into different configurations of reduced mirror size and simpler instrument complement. The challenge is to conceive of a mission design that absorbs former NASA contributions (science and mission operations, launcher, spacecraft bus, assembly and test etc...) within the new cost ceiling while maintaining a compelling science case that retains a significant fraction of the IXO scientific objectives. A newly appointed Science Team (including NASA and JAXA-“observers”) was briefed on the possible configurations and evaluated their respective scientific merits and associated cost and risk factors.

A concept, christened Athena (Advanced Telescope for High Energy Astrophysics), has been selected for further study by the Science Team. It comprises two Silicon Pore Optics telescopes focussing X-rays onto two fixed focal plane instruments: a cryogenic X-ray spectrometer and a wide field imager with high time resolution capability. The combined telescope effective area would be  $\sim 1.15 \text{ m}^2$  at 1 keV and  $0.5 \text{ m}^2$  at 6 keV (TBC). The concept is currently being elaborated upon with the support of ESTEC technical teams. This internal zero-order assessment will later be subjected to a more thorough validation by industry from June to September.

Science performance simulators are being developed to facilitate participation by the scientific community in design trade-offs and in the elaboration of the scientific case. A science workshop will be held at MPE-Garching from 14 to 16 June to review Athena's expected performances and collect inputs from the community on the scientific objectives of the mission. These inputs will form the basis of the Athena science case as it will appear in the future Yellow Book.

### **9.3 New Gravitational Wave Observatory: Oliver Jennrich**

On February 3, B. Schulz (AEI) and the ESA Study Manager, A. Gianolio, presented the results of the LISA assessment studies at the L-class mission public presentation in Paris.

Following the decision to terminate the LISA project, the LISA International Science Team was dissolved. A new science team was appointed in April to assist in the study of an ESA-only mission, provisionally baptized NGO, for New Gravitational Observatory. The NGO Science Team comprises ten European scientists plus one observer from NASA. At its first meeting on 13-14 April, the Science Team was informed about the programmatic situation and revised L-class missions schedule and started planning its activities. The team met again on 17 May to discuss and agree on a baseline concept for NGO. This concept will be subjected to a zero-order internal assessment study that will be performed at the Concurrent Design Facility (CDF) from June 15 to July 9. A science case taskforce - comprising members of the NGO science team supplemented by scientists from 15 different institutes- is in parallel investigating the scientific capabilities of the NGO concept and drafting the Yellow Book.

Planned long before the termination of LISA, scientific meetings have been held in Milan ("Bridging electromagnetic astrophysics and cosmology with gravitational waves") and in Paris (regular "LISA France" meeting) during which the audience was informed about the new paradigm for L missions and the plans for a Europe-only gravitational wave observatory. The scientific community reacted quite positively and unanimously agreed to continue working on the 4<sup>th</sup> Mock LISA Data Challenge (MLDC), though with a relaxed deadline. Moreover, a tenth institute formally joined the LISA-France collaboration.

Technology development activities planned for LISA continue since they will be needed by NGO as well. If required, these activities will be re-directed to focus on the specific needs of NGO once the mission is better defined.

### **9.4 EChO: Kate Isaak**

EChO is one of the four M3 mission candidates selected by the advisory structure for an assessment study. The Science Team has been appointed and held its first meeting on the 3<sup>rd</sup> of May. Team members include Giovanna Tinetti (UK - contact person), Pierre Drossart (F), Oliver Krause (DE), Christophe Lovis (F), Marc Ollivier (F), Ignasi Ribas (E), Ignas Snellen (NL) and Bruce Swinyard (UK). The team is currently finalising the Science Requirements Document (SciRD) and will formally issue it on May 23, in preparation for the Concurrent Design Facility (CDF) sessions that will take place in June.

## **9.5 LOFT: David Lumb**

LOFT is one of the four M3 mission candidates selected by the advisory structure for an assessment study. Contrary to the letter of support appended to the proposal, the Italian space agency ASI was unwilling to support LOFT. A new consortium had therefore to be assembled to support the payload study. The consortium, led by Dutch and Swiss institutes, is currently reorganising its internal distribution of activities in anticipation of the upcoming request for Letters of Intent for payload studies. A Science Team is currently in the process of being appointed, consisting of Michiel vd Klis (NL), Luigi Stella (I), Marco Feroci (I), Jan-Willem den Herder (NL), Martin Pohl (CH), Andrea Santangelo (D), Silvia Zane (UK), Margarita Hernanz (E), Didier Barret (F), Soeren Brandt (DK). A short zero-order ESA internal assessment is planned to start with a Concurrent Design Facility session during the month of September 2011.

## **9.6 STE-QUEST: Luigi Cacciapuoti**

STE-QUEST is one of the four M3 mission candidates selected by the advisory structure for an assessment study. Its goal is to test different aspects of the Einstein's Equivalence Principle by performing clock red-shift measurements at different locations in the earth (and Sun) gravitational fields and by tracking the free propagation of matter waves of different composition.

The STE-QUEST Science Study Team was officially appointed by the Director of Science & Robotic Exploration. Team members include K. Bongs (UK), P. Bouyer (F), L. Iess (I), A. Landragin (F), E. Rasel (D), S. Schiller (D), U. Sterr (D), G. Tino (I), and P. Wolf (F). During its first meeting at ESTEC on April 19, the team reviewed the draft STE-QUEST Science Requirements document prepared by the study scientist. The document was eventually agreed upon and issued on April 26. It forms the basis for the internal assessment phase currently in progress at the ESTEC Concurrent Design Facility (CDF) from May 11 to early June. The study report will be available by mid-June.

In parallel, ESA is conducting a review to assess the readiness of the atom interferometer technology. The review was kicked-off on April 27 with the support from members of the Science Study Team and by the DLR group working on the QUANTUS experiment. The review outcome is also expected by mid-June 2011.

# **10 Projects under development**

## **10.1 Gaia: Timo Prusti**

The Mission level Critical Design Review (M-CDR) was successfully completed in April. The end-to-end scientific performances of Gaia were recalculated and consolidated taking into account all findings from the Spacecraft-level CDR. The performances remain essentially unchanged which enhances confidence in their validity. These performances have now been posted on the Gaia web site in a form specified by the Gaia Science Team (GST) as being most useful to the scientific community.

Integration of the spacecraft continues at full speed. The mounting and precise alignment of optical elements onto the Silicon Carbide optical bench is a delicate and lengthy process. One complete telescope - all 6 flight mirrors for one line-of-sight - has nevertheless been successfully installed and aligned. This ensemble will be submitted to a series of critical vibration tests during the summer. All Proximity Electronic Modules have been delivered and integration of the CCDs onto the Focal Plane Assembly (FPA) is in progress. All astrometric and blue photometer CCDs have been attached to the support structure. Integration of red photometer and radial velocity spectrometer CCDs in a different plane of the FPA will follow soon. A new design of the Deployable Sunshield

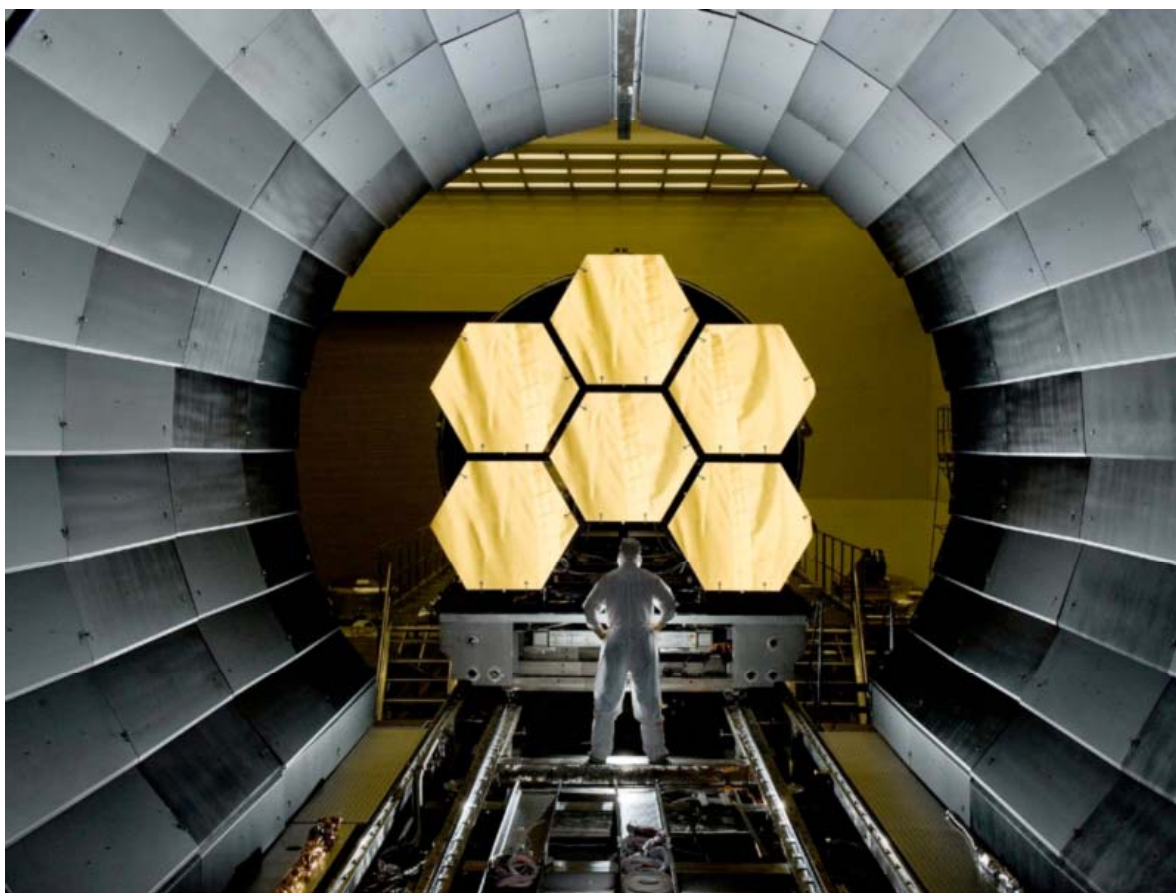
Assembly (DSA) has been validated which provides sufficient torque margins during deployment. The current Gaia launch date is May 2013 without any contingency margin.

The call for Letters of Interest to participate in the Gaia Archive Preparation group (GAP) attracted 21 responses. The mandate of GAP is to prepare the Announcement of Opportunity for and supervise the selection of the Archive Access Coordination Unit (CU), the ninth and last CU of the Data Analysis & Processing Consortium (DPAC). Once CU9 is established, GAP will be disbanded. The process is expected to last about one year. The GST and the executive committee of the DPAC are in parallel finalizing the Gaia data release policy. Data releases and access to the archives will be discussed with the wider European astronomical community at the plenary meeting of the FP7 Initial Training Network GREAT (Gaia Research for European Astronomy Training). The GREAT meeting will take place in Brussels between 21 and 23 June.

In response to an ESO AO for public surveys, the Gaia community submitted a proposal requesting 300 nights of VLT time to perform a spectroscopic survey of the milky-way. The proposal, signed by over 250 scientists, has G. Gilmore (IoA Cambridge, former member of the GST) and M.S. Randich (Arcetri, current member of the GST) as co-PIs.

## **10.2 JWST: Peter Jakobsen**

The NASA JWST Project and NASA HQ are still in the process of establishing a revised budget and schedule for JWST. The NASA Project is presently working to a new launch date in October 2018. The new plan will be submitted to the NASA Agency Program Management Council for approval in the June/July time frame.



**JWST Primary Mirror Segments being prepared for Acceptance Testing**

The ongoing US fiscal problems notwithstanding, steady technical progress continues to be made throughout the project. At the time of writing, a total of 12 of the 18 flight JWST

Primary Mirror Segments had successfully completed optical polishing; 11 of these have been gold-coated, and 6 of these are undergoing final acceptance cryogenic testing (see figure above). The four flight JWST science instruments are all in various stages of final assembly and testing, with the two European instruments currently leading the pack.

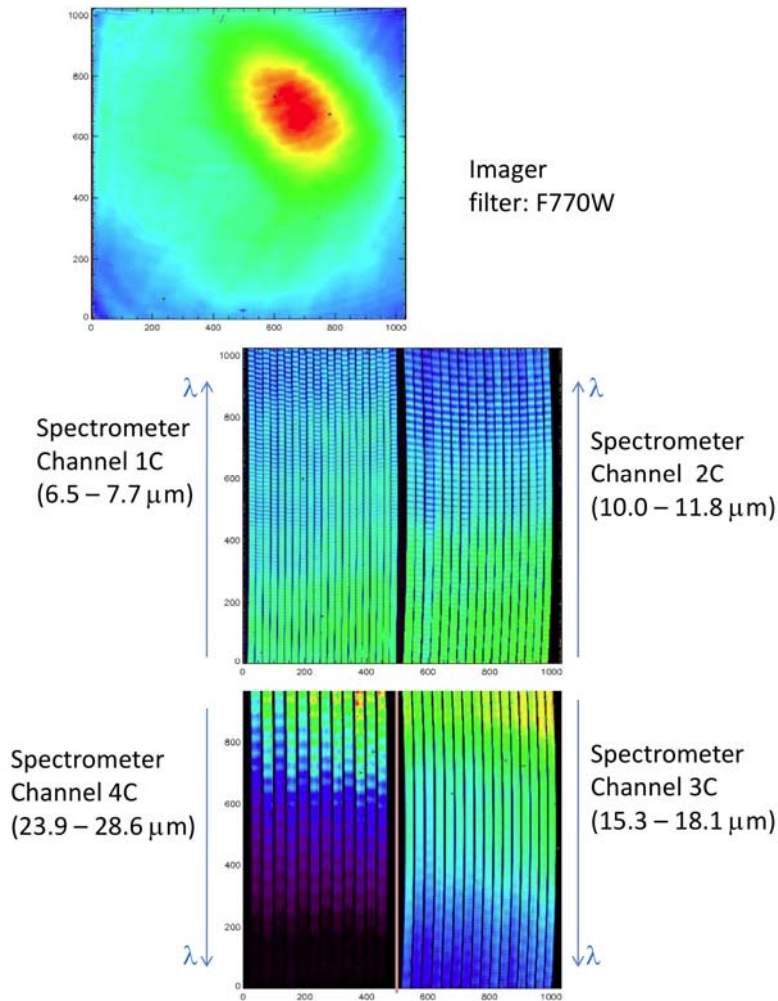
Post vibration inspection of the fully assembled NIRSpec flight instrument revealed that the Micro Shutter Array (MSA) had developed 20 new partially closed shutters since the MSA was delivered to Astrium. These failed shutters are caused by particulate contamination in the form of  $\sim 100\text{ }\mu\text{m}$  long fibres that prevent the shutter doors from closing properly. Because of the danger of permanently damaging the MSA, the first cycle of the NIRSpec cryogenic test and calibration campaign was therefore restricted to the objective of mechanically and optically verifying as many instrument functionalities as possible without operating the MSA. These tests were carried out during February-March and demonstrated both the functionality and very high quality of the NIRSpec optics and the excellent throughput of the instrument. Following the first cryogenic tests, the MSA was removed from NIRSpec, and cleansed of the contaminating fibres. However the removal process left many of the affected shutter doors in a warped or not properly closed state. These shutters have recently been “plugged” and turned into much more benign permanently closed shutters. Efforts to establish the origin of the contaminating fibres are still in progress.

The post-test inspection unfortunately also uncovered two further potential contamination and quality control issues with NIRSpec. The first issue concerns the NIRSpec cable harness. Careful inspection after the first part of the NIRSpec cryogenic campaign revealed that the thin ( $\sim 2.5\text{ }\mu\text{m}$ ) outer Teflon coating of the wiring has started to “blister” and separate from the Kapton insulator. While this phenomenon does not affect the electrical functioning of the harness, it is a potential source of particle contamination. One possible fix may be to encase the harnesses by wrapping them with Teflon tape. This could be done, at least partly, without completely dismantling the instrument. The second new issue is potentially more serious. During assembly of NIRSpec, the prime contractor opted to secure a number of minor wires in the instrument by gluing them directly to the SiC optical bench by means of localized gobs of thick epoxy. Post-testing inspection revealed that many of these epoxy gobs had separated from the SiC during cryogenic cycling. What is worse, four of the gobs had pulled out a piece of the underlying SiC with them, leaving a shallow crater-like chip in the structure. At the time of writing it has not been established whether any of the chipped glue locations harbour cracks that threaten the mechanical integrity of the instrument. Even if it can be established that there are no cracks at this time, it may still be necessary to mechanically grind down and smooth out the chips by polishing to prevent cracks from developing in the future. The NIRSpec schedule is presently on hold while these new problems are being investigated. Depending on the outcome of the investigations, a fix to these two problems may delay the delivery of NIRSpec to NASA by 2 to 8 months.

A generic problem has also emerged with the long wavelength Teledyne  $5\text{-}\mu\text{m}$  cut-off HgCdTe detector arrays employed by all three near-IR JWST instruments. The majority of the devices produced to date suffer from a gradual secular increase in the number of hot pixels. Both the present NIRSpec flight and spare detectors are affected to the point that they are no longer flight-worthy. The NASA Failure Review Board which investigated the problem concluded that migration of Indium from the bump bonds into the HgCdTe substrate is the likely reason for the problem. This raises the expectation that NASA will fund Teledyne to manufacture a new batch of improved  $5\text{-}\mu\text{m}$  detectors for installation in all three JWST near-IR instruments at some point in the future.



MIRI FM “Internal First Light”: On-board calibration sources  
the stretch of each image has been chosen to show structure, the data level is approximately as expected.



The MIRI flight instrument is fully assembled and is currently undergoing cryogenic testing and calibration. The operational temperature of 6 K and first-light using internal calibration sources were achieved on 10 May (see figure above). The instrument continues to suffer from a number of issues with its JPL-provided detectors. The instrument software will be patched later in the campaign to alleviate or circumvent these problems. The initial part of the campaign therefore focuses on tests that can be performed with the detectors in their current state, such as optical alignment and basic optical performance characterisation. Radiometric calibration will start once the detector issues are resolved.

Led by the Project Scientist, the small ESTEC-based JWST operations team designed planned and executed the NIRSpec cryogenic calibration campaign at IABG and documented and analysed the data obtained. The team participated actively in the diagnosis of the hot pixel problem. Together with the JWST operations group at STScI, it continued to develop NIRSpec operations procedures and software. It organised and chaired a meeting of the NIRSpec Instrument Science Team held at Astrium premises on the 2<sup>nd</sup> and 3<sup>rd</sup> of March and supported a meeting of the JWST Science Working Group held at Northrop-Grumman on 9-10 March and associated weekly teleconferences. In the framework of the FP7 ELIXIR Training Network, the team organised a “Training School” on the topic of “How does a Space Project work?” to be held at ESTEC on 19 & 20 May.



### 10.3 Lisa Pathfinder: McNamara

The launch composite environmental test campaign of the LISA Pathfinder (LPF) spacecraft and propulsion module is in progress. The three-axis sine test was successfully completed at IABG (Munich) during the month of April, followed by a Short Functional Tests (SFT) to verify that no damage had occurred during the vibrations. The spacecraft and propulsion module will stay at IABG for the remainder of the environmental test campaign. In the coming months, the remaining electronic boxes of the LISA Technology Package (LTP) - the front-end electronics, the UV lamp unit, the three-axis magnetometers and the Thermal Optical Qualification Model (TOQM) of the inertial sensors and optical bench - will be integrated into the spacecraft. The spacecraft will then be submitted to Electro-Magnetic Compatibility (EMC) tests scheduled to start in July.

In parallel, the propulsion module and Structural Thermal Model (STM) of the spacecraft are being prepared for a separation shock tests from the VEGA launcher that will take place in July. This test was not initially foreseen since the spacecraft has already been successfully qualified to previously specified launcher shock levels. In October 2010 however, VEGA raised the launcher upper-stage separation shock levels significantly above LISA Pathfinder design specifications. The true shock levels will only be known after the first VEGA qualification flight, scheduled at the end of this year.

After EMC tests, the spacecraft will be submitted to thermal vacuum test followed by Integrated System Tests. Once these tests are completed in November, the spacecraft and propulsion module will be put into hibernation awaiting the delivery of the LTP Core Assembly.

As mentioned above, nearly all electronic units of the LTP have been delivered. One notable exception is the caging mechanism launch-lock that holds the test masses during launch and releases them with near-zero velocity once in orbit. A dedicated project-level review of the launch lock was held during the latter half of April. Two mechanisms were presented as alternatives to the hydraulic launch lock actuator the development of which has been stopped: a direct form-fit-function replacement for the hydraulic device; and a single-shot mechanism located external to the inertial sensor vacuum enclosure. The former relies on a series of gears driven by a piezoelectric motor. A breadboard has been manufactured which confirms that the device meets the driving requirements. Several open issues remain however in particular related to the availability of space-qualified piezoelectric motors and non-magnetic bearings. The single-shot device relies on a paraffin actuator coupled to a transmission mechanism which links to the test-mass fingers. This device is simpler and potentially quicker to develop, but there was no time to manufacture and test a full breadboard of the mechanism prior to the review. The Board recommended that both mechanisms be further developed to reach the level of a Preliminary Design Review (PDR) by September, after which one of the two will be selected as the new baseline for LISA Pathfinder.

In addition to the launch lock review, the project is also performing an agency-level review of the micro-propulsion system. The aim of the review is to assess the status of the Caesium Field-Emission Electric Propulsion (FEEP) thrusters currently baselined for LISA Pathfinder as well as four alternative micro-Newton propulsion technologies: Cold Gas thrusters as developed for GAIA; Colloidal micro-Newton thrusters as employed by the NASA-provided Disturbance Reduction System (DRS) onboard LISA Pathfinder; micro Radio-frequency Ionisation Thrusters ( $\mu$ -RITS); and Indium FEEP thrusters. Preliminary findings favour Cold Gas thrusters and  $\mu$ -RITS though various issues need to be resolved before any decision is taken. The Review Board Meeting is scheduled on May 16.

The LISA Pathfinder Science Working Team (SWT) met at ESTEC on the 4<sup>th</sup> of May. The SWT was asked to comment on the new caging mechanism launch lock. Since the new design does not violate any agreed-upon science requirements, the SWT could only comment on associated schedule risks.

Development of the data analysis software is proceeding nominally. Inclusion of a simplified linear model of the LPF has provided the data analysis and science operations team with a much better understanding of the overall system. In doing so, they have also found several inconsistencies with the industry provided non-linear simulator.

LISA Pathfinder was well represented at the recent “*Rencontres de Moriond*” Symposium on gravitational physics. Three invited talks were given covering the mission, the experiment, and the ground testing and route toward LISA. The possibility of using LPF to test the Modified Newtonian Dynamics (MOND) theory was the subject of a 4<sup>th</sup> presentation which received a surprisingly high level of support from the audience.

#### **10.4 ASTRO-H: David Lumb**

The ESA participation in the JAXA-led Astro-H project was approved by the SPC at its February meeting. The instruments and spacecraft subsystems are progressing through a series of Preliminary Design Reviews. The impact of the March earthquake has not been fully assessed yet but JAXA informally acknowledges that a delay of several months is likely. An Invitation-To-Tender (ITT) was released for industry to procure loop heat pipes, BGO scintillators, power supplies and mirror coating materials.

### **11 Satellites in orbit**

#### **11.1 Herschel: Göran Pilbratt**

As of early May 2011 Herschel has executed about 80% of the Key-Programme (KP) Guaranteed Time (GT) and 77% of the KP Open Time (OT) observations, as well as 56% of the GT1 and 2.1% of OT1. The emphasis is still on Key-Programmes but will gradually move to OT1 programmes in the coming months. Herschel generally operates quite well and produces good science data. The fraction of observing time that has been lost since launch is ~4%, the main cause being Single Event Upsets (SEU) which corrupt the memory content of the science instruments.

GRB observations required rapid re-planning on two occasions. The system responded efficiently but no afterglows were detected. The “triggering criteria” are being refined to maximise the probability of success so as to avoid wasting precious observing time and draining ground segment resources.

Consolidation of the 241 OT1 accepted observing programmes took longer than anticipated mainly due to the need to resolve conflicting observations, i.e. observations of overlapping fields by different proposers. With a couple of exceptions, all OT1 observations could nevertheless be released before the second in-flight call for guaranteed time (GT2) proposals was issued on April 7. Thirty-two proposals were received by the deadline of 12 May. The amount of GT2 time to be allocated is 362 hours.

The Call for open time (OT2) proposals will be issued on the 9<sup>th</sup> of June with a deadline of 15 September. The OT2 HOTAC will meet on 8-11 November 2011 at ESAC. To assist potential OT2 observers, an observing planning workshop will take place on 20-21 June simultaneously at ESAC and at the NASA Herschel Science Centre in Pasadena.

OT2 will be the last call for Herschel observing proposals. The amount of observing time to offer in OT2 is uncertain since it depends on the poorly determined mission lifetime. To reduce the uncertainty, a third Direct Liquid Content Measurement (DLCM) will be

carried on the 24<sup>th</sup> of May that will hopefully provide a better estimate of the amount of superfluid helium remaining on-board. In the meantime an analysis of the PACS and SPIRE He-3 instrument cooler periodic recyclings performed by the PACS team yielded convincing results which agree well with the end-of-mission date predicted by a simple linear extrapolation of the 2 first DLCMs. The current best prediction is for the mission to end in October-November 2012, significantly earlier than was assumed at the time of the OT1 call (March 2013). As a result, the amount of observing time available for OT2 is relatively small, an unwelcome situation which has been extensively discussed by both the Herschel Science Team and the Herschel Users' Group. The outcome of these discussions is now being consolidated to form the basis for the "rules" for OT2 time allocation..

The Herschel Users' Group (HUG) has been extended to its full complement of 12 by adding four scientists from the OT1 community. The HUG held its 3<sup>rd</sup> and 4<sup>th</sup> meetings at ESAC on 23-24 February and on 3-4 May, respectively. It has provided prioritised recommendations on the conduct of operations and the use of Herschel in general.

An agreement has been reached concerning the cross-calibration of Herschel and Planck by which HFI data will be supplied to the HSC for use in the calibration of SPIRE photometric maps.

At the time of writing, 246 articles based on Herschel observations have been published in the refereed literature since launch. This figure does not include a rapidly increasing number of "indirect papers", i.e. articles resulting from Herschel follow-up observations with other ground or space-based facilities.

## **11.2 Planck: Jan Tauber**

Operations continue to run quite smoothly and efficiently. Planck is now well into its fourth all-sky survey. The fifth sky survey will start this summer. The scanning pattern will be modified compared to surveys 1-4 so as to optimise the characterisation of specific systematics related to polarisation and map-making.

It is currently estimated that the HFI will continue to operate until the end of January 2012 after which it will run out of Helium. The approved LFI-only phase of operations will start immediately after. The sorption cooler which is required to cool LFI is now expected to last at least 6 months. A detailed plan for scanning the sky in this phase is being prepared, based on the approved "deep rings" concept.

The LFI and HFI data processing pipelines are working routinely from end to end. The software is continuously upgraded as understanding of instrumental and other systematic effects gradually improves. The current focus of attention is on achieving the high calibration accuracy required for Planck to meet its scientific objectives. The LFI and HFI Data Processing Centres regularly exchange data for cross-calibration purpose and joint processing.

The first Planck public conference, "*The millimetre and sub-millimetre sky in the Planck mission era*", was held in Paris, Cité des Sciences, between 10 and 14 January 2011 (web site <http://www.planck2011.fr>). The Early Release Compact Source Catalogue (ERCSC) was released during the conference on January 11 via the Planck Legacy Archive web interface developed at ESAC. The ERCSC consists of nine lists of foreground sources detected in each of Planck's frequency channels. The catalogue is unique in several respects: it has the widest frequency coverage of any all-sky catalogue produced by a single experiment and it contains the first all-sky inventory of sources at sub-millimetre wavelengths. Optimised to detect the coldest objects, it is also the first catalogue to cover the complete zoo of extragalactic sources, all the way from radio and infrared-luminous galaxies to clusters of galaxies. The ERCSC also incorporates two dedicated resources: a

sub-catalogue of 189 galaxy cluster candidates detected via the characteristic signature they imprint on the CMB through the Sunyaev-Zel'dovich effect, and the Early Cold Cores Catalogue, comprising 915 molecular cloud cores with temperature below 14 K, the ambient dust temperature in the Galaxy. The ERCSC archive interface provides powerful search capabilities and interoperates with the CDS via the Virtual Observatory functionality. It is being regularly accessed ~20 times per week on average. More than 2000 data set have been retrieved so far without problems.

Thanks to the early release of the catalogue it is possible to exploit the synergy with ESA's infrared observatory Herschel. Planck and Herschel have a significant overlap in wavelengths and the possibility of mapping with Herschel's higher resolution a series of targets identified by Planck is rather unique. Other important follow up opportunities are offered by ESA's X-ray observatory, XMM-Newton, which complements Planck's observations of galaxy clusters by targeting their hot gas emission, as well as by a number of ground-based or airborne facilities, including the Australian Telescope Compact Array (ATCA), the NRAO's Very Large Array (VLA), the Atacama Large Millimeter/Sub-millimeter Array (ALMA), and the NASA/DLR Stratospheric Observatory for Infrared Astronomy (SOFIA). Three articles have already been posted on astro-ph based on follow-up observations of Planck ERCSC/ESZ sources. Simultaneously with the release of the ERCSC, 25 scientific papers authored by the Planck collaboration were posted on astro-ph and submitted to Astronomy & Astrophysics. These articles will become part of an A&A special issue.

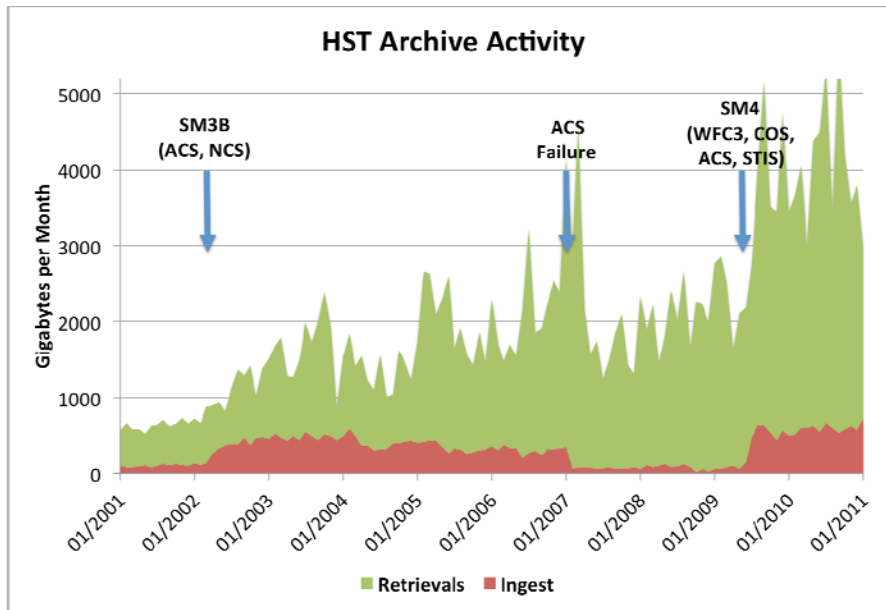
The release of the ERCSC on January 2011 was accompanied by a press conference in Paris, and the release of several articles on ESA's web sites. The press conference was well attended; it was also webcast live to the world. Parallel media events took place at the AAS meeting in Seattle and in Rome (organised by ASI). ESA's outreach office evaluates the impact in the European media as "satisfactory".

In view of the delivery of data products by the two Planck Data Processing Centres to ESA in December 2012, a mid-course "peer review" of the status of data processing and analysis will take place at the end of June at ESAC.

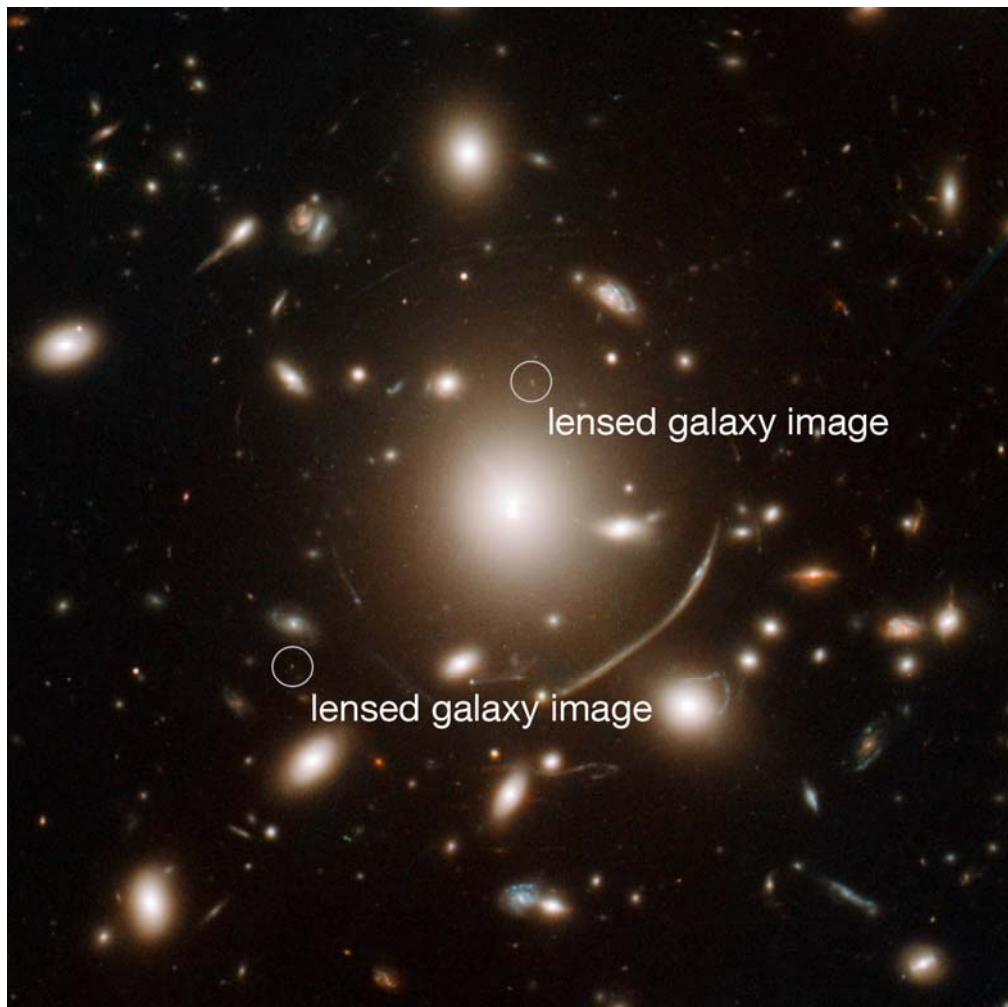
### **11.3 HST: Antonella Nota**

On April 24, the Hubble Space Telescope celebrated the 21<sup>st</sup> anniversary of its launch. The observatory continues performing well, with a consistently high observing efficiency of ~50%. The payload status is nominal.

Community interest in Hubble remains high. In response to the Cycle 19 Call for proposals, STScI received 1008 proposals, corresponding to an over-subscription in time of 7. Two hundreds proposals (20%) have a European PI and 1801 investigators out of 5793 (31%) are from an ESA member state. The breakdown by requested instrument usage is 47% for WFC3, 22% for ACS, 16% for COS, 12% for STIS, 2% for NICMOS, and 1% for FGS. The Time Allocation Committee – which includes 29 European scientists - will meet at STScI from 16 to 20 May and the results of the selection will be announced in mid-June.



With over 10,000 registered archive users worldwide archival research is a growing source of Hubble's scientific productivity. As shown in the figure above, the number of archive retrievals doubled after Servicing Mission 4. The Hubble Legacy Archive (HLA) contains a set of advanced data products and tools which are designed to facilitate the scientific exploitation of Hubble data. Opened on March 8, HLA Data Release 5 includes major improvements and in particular a completely re-engineered footprint interface that allows users to interactively select data, both graphically and from the associated table view.



Thanks to Hubble WFC3 and ACS observations of the galaxy cluster Abell 383, Johan Richard and collaborators (MNRAS 2011 in press, [arXiv:1102.5092v2](https://arxiv.org/abs/1102.5092v2)) recently uncovered a gravitationally lensed galaxy at a redshift of 6.027 (see picture above). Combining HST and Spitzer data, the authors obtain a 7 photometric data-points spectral energy distribution which is best fit by an  $\sim 800$  million years old stellar population model. Since the age of the universe at a redshift of 6.027 is 950 million years, this implies that this galaxy must have started forming stars a mere 150 million years after the big-bang. If sufficiently numerous, such early forming galaxies could account for the re-ionisation of the universe.

At the time of writing, 9550 papers based on Hubble observations have been published in the refereed literature, of which 164 are from 2011.

#### **11.4 XMM-Newton: Norbert Schartel**

The XMM-Newton observatory continues to operate nominally. As of May 1, 97.8% of priority A and B AO-9 observing programmes had been completed as well as 45.8% of priority C observations. The 12 outstanding A and B priority observations are to be carried-out simultaneously with other observatories over the next few months. AO-10 observations started on May 1<sup>st</sup>.

Three hundred participants have registered for the “The X-ray Universe 2011” symposium that will take place from 27 to 30 June in Berlin. The scientific organising committee received requests for 260 oral presentations and 110 poster contributions.

MNRAS published a letter (2011, MNRAS 412, L11) by O.K. Madej and P.O. Jonker reporting the discovery of a broad emission feature at  $\sim 0.7$  keV in the spectra of the ultra-compact X-ray binary system 4U 1543-624. The spectra had been obtained with the high-resolution spectrographs on-board XMM-Newton and Chandra. In this system, the donor star is a CO or ONe white dwarf which transfers oxygen-rich material to a neutron star. The broad 0.7 keV feature most likely originates from reprocessing of the X-rays in the oxygen-enriched accretion disc giving rise to a prominent O VIII Ly $\alpha$  emission line. The authors also confirm the detection of a weak Fe K $\alpha$  emission feature at  $\sim 6.6$  keV also originating from X-rays reflected off the accretion disc. Both lines are broadened by general relativistic effects in the strong gravitational field of the neutron star. Such broad lines may ultimately offer the possibility to determine the radius of neutron stars which, coupled with measurements of the gravitational field, would set strong constraints on the equation of state of matter inside neutron stars.

Gobat and collaborators reported the discovery of a mature galaxy cluster at a redshift of 2.07 (A&A 526, 133, 2011). Beside its record breaking distance, what makes the object unique is the fact that it is a fully mature cluster as evidenced by its diffuse X-ray emission and its population of evolved red galaxies. Its mass lies in the range  $5$  to  $8 \cdot 10^{13} M_{\odot}$  comparable to that of Virgo. That mature galaxy clusters existed as early as 3 billion years after the big-bang came as a surprise. The discovery was the subject of a web story on the ESA SciTech portal that was picked up by Nature (research highlights), Spanish newspapers and discovery channel.

At the time of writing, 2,777 articles based on XMM-Newton observations have been published in the refereed literature, of which 119 are from 2011.

#### **11.5 Integral: Christoph Winkler**

The spacecraft, payload and ground segment continue to perform nominally. The 17<sup>th</sup> annealing was successfully carried-out from 26 April to 13 May and restored the resolution of the SPI detectors.

Several Target of Opportunity (ToO) observations were carried-out over the reporting period. The Be radio pulsar binary PSR B1259/63 was observed on January 22-23 as part of a large multi-wavelength monitoring campaign. The Be/X-ray binary system A0535+26 was observed on the 23<sup>rd</sup> of February during a giant outburst. A newly discovered high-mass X-ray binary in the SMC was observed on April 2. In addition, GRB 110112B and 110206A were detected by INTEGRAL in the IBIS FOV.

The 9<sup>th</sup> Announcement of Opportunity (AO-9) for INTEGRAL observing proposals was released on 7 March. By the deadline of April 15, 49 proposals had been submitted, including 18 proposals for long (>1 Ms) exposures and 25 proposals for ToO observations. The total requested observing time amounts to 70 Ms, resulting in an over-subscription in time of 2.9. The Time Allocation Committee will meet at ESAC from 6 to 9 June.

The Terms of Reference (ToR) of the INTEGRAL Users Group (IUG) have been updated such that membership duration increased from 2 to 4 years, aligned with that of XMM-Newton. Angela Bazzano (IASF, Rome) took-over the IUG chairmanship and two new scientists, Mikhail Revnivtsev (MPE Garching) and Jacco Vink (Utrecht), were appointed to replace Dr. Postnov and Prof. Wilms whose term had expired.

Upon recommendation from the IUG, a series of new observations of the Cosmic Diffuse X-ray Background (CXB) will be carried-out over the next few years. The goal is to achieve a much better characterisation of the 3-300 keV CXB spectrum than had been possible with the relatively short 2006 observations. Such observations are complex as they require pointing the telescope toward the earth. Beside longer exposure times, the new observations will also benefit from a better configuration of the Earth with respect to the sky background and reduced earth atmospheric emission due to decreased cosmic-ray-induced activity at solar maximum. Starting in 2012 (AO-9) and continuing in 2013 (AO-10) and 2014 (AO-11), about 230 ksec of observing time per year will be used for this purpose, plus ~25% overhead due to special slews and safe pointings before and after each exposure. All CXB data will be made public immediately.

In the March 24 issue of Science Express, Laurent et al report the discovery of polarised gamma ray emission from the black-hole binary Cygnus X-1. This polarised emission is confined to the energy range above 400 keV where a distinct harder component dominates the spectrum of Cyg X-1. Clearly, this high energy component must have a different origin than the Compton coronal emission which operates over the 20-400 keV range. Taken together, the spectral shape and polarisation almost guarantee that this high energy component originates from synchrotron self-compton emission in the radio-jet of Cyg X-1. This led to a web story released simultaneously on the SciTech and ESA Science portal.

The INTEGRAL workshop “The INTEGRAL Legacy: Extreme, Variable High Energy Sky” will be held in Chia Laguna (Italy) from 19 to 23 September.

At the end of March, the total number of refereed publications based on INTEGRAL data was 606.

## **11.6 Suzaku (ASTRO-E2): Arvind Parmar**

The Japanese-US X-ray astronomy mission Suzaku was launched in July 2005 and following the early failure of its prime instrument is performing astronomical observations with the remaining X-ray CCD cameras and hard X-ray detector. Scientists from institutes in ESA Member States appear as authors of 114 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.



AO-6 observations started on April 2011. The approved target list of European AO-6 observations can be consulted at <http://www.rssd.esa.int/suzaku>. There are 10 European proposals in Priorities A and B (16 pointings) for a total of 1,021 ksec and 6 Priority C targets (fillers) for a total of 610 ksec. As in previous AOs, European observations account for about 8% of the total open time.

#### **11.7 Akari (ASTRO-F): Alberto Salama**

Further to the cryo-cooler curing operations in November 2010, the detector temperature decreased, but eventually stabilised at 52 K, five degree above the maximum value required for scientific observations. All efforts to reduce the temperature further by adjusting the cryo-cooler driving voltage failed and were eventually abandoned in April. It appears that the Open Time observations cannot be restarted. A public announcement by JAXA is expected in mid summer. To date, 154 articles based on AKARI data have been published in the refereed literature, of which 11 are from 2011. About 30% of AKARI articles have European co-authors.

#### **11.8 CoRoT: Malcolm Fridlund**

The spacecraft continues to operate nominally but without Data Processing Unit chain #1 which failed in April 2009. After more than 1,600 fays in space, CoRoT has accumulated 162,000 uninterrupted light-curves of durations comprised between 24 and 152 days.

Scientific results from CoRoT appear in the refereed literature at a rate of 2 articles per week. A special issue of Astrophysics and Space Science will be published on the occasion of the second CoRoT symposium that will be held from 13 to 17 June in Marseille. The number of confirmed exo-planets is 25, including 4 new objects that will be announced in Marseille.

At the beginning of July, the satellite will be pointed again towards CoRoT-9b a Saturn-size planet orbiting a solar type star (G3V) in 95 days. The shape of the light-curve during the transit will be searched for indications of the presence of an earth-size moon around CoRoT-9b. Variations in the time of the eclipse will also be looked for as these would indicate the presence of other smaller non-transiting, planets orbiting the same star.

The Canadian MOST satellite recently detected the first transit in the light-curve of 55 Cnc previously known from radial velocity observations to harbour a planet labelled 'e'. With CoRoT-7b and Kepler-10B, 55 Cnc e constitutes the third example of a planet whose mass is only a few times that of the earth and which orbits a solar type star with a period less than one day. All three planets have a density of  $\sim 10 \text{ g/cm}^3$ . The existence of such planets represents a challenge for theoretical models.

The total number of refereed scientific publications based on CoRoT data is 350, of which 42 are from 2011.