2010 Pre-graduate projects at the European Space Astronomy Centre ESAC

1 Introduction 2

2 Project Concept 3

3 Projects 4

3.1 Epic pattern characteristics 4

3.2 XMM-Newton source catalogue 4

3.3 X-raying the gaseous environment of supermassive black holes 5

3.4 Neutron stars and black holes on the edge 5

3.5 Gallery of selected galactic supernova remnants 6

3.6 X-rays vanishing in the interstellar medium 6

3.7 Parallel 3D models of the flow in the colliding winds of binary systems of hot stars 6

3.8 Analysis of Gravitational Microlensing events observed with the OSIRIS narrow angle camera on the Rosetta spacecraft 7

3.9 Scheduling Optional Tasks in an Over-Constrained System of Dependent N-ary Resources 7

3.10 Study and Application of Superresolution Techniques to the Images from the OSIRIS cameras onboard Rosetta 8

3.11 Automated Analysis of Large Planetary Datasets 8

3.12 Database development for science data of the CIRS infrared spectrometer on-board the Cassini Spacecraft 9

3.13 Geometry Analysis for Planetary Science Planning 9

3.14 Test and optimisation of a setup to record meteors as a tracer of cometary properties 10

3.15 Pulse profile evolution in GX 1+4 10

3.16 Simplified access to INTEGRAL data, data products and visualization tools 10

3.17 Study of the properties of a selected sample of X-ray bursters with INTEGRAL 11

3.18 Weighing the densest stars in the universe 11

3.19 Study of extended far-infrared diffuse emission structure in star forming regions based on Herschel large-scale maps 12

3.20 Gaia. Young stars spectroscopic library 12

3.21 Lithium and other chemical abundances in open clusters 13

3.22 Very high energy gamma-ray spectra in the Virtual Observatory 13

4 More Information 15

For more information please contact: Deborah.Baines@sciops.esa.int

1 Introduction

The European Space Astronomy Centre (ESAC) is the ESA centre that specialises in astronomy and space science. It is located in Villafranca del Castillo, Villanueva de la Cañada, close to Madrid in Spain, and hosts the science operation centres for all ESA astronomy and planetary missions together with their scientific archives.

Figure 1-1: The European Space Astronomy Centre ESAC

Space telescopes are our 'eyes' in the heavens. From their superior positions of observation high above the Earth's atmosphere, they provide us with astounding views of the Universe. ESAC is where those views are first studied - data on black holes, distant galaxies, neighbouring planets as well as those far beyond our solar system are beamed back to the Madrid countryside. As the 'home' of all ESA's space-telescope and planetary missions, ESAC is the science operations centre for these missions and the site where all the scientific data produced is studied and archived so that it can be made accessible to the world.

In addition, ESAC also hosts the Spanish Laboratory for Space Astrophysics and Fundamental Physics (LAEX, formally known as LAEFF), an innovative research facility aimed mainly at encouraging young Spanish scientists to enter the fields of astrophysics and fundamental physics.

We offer the possibility for students to perform training at ESAC and the collocated LAEX institute. The trainees will be integrated in the respective working teams. In section 3 we list the projects that are being offered at ESAC and LAEX in 2010.


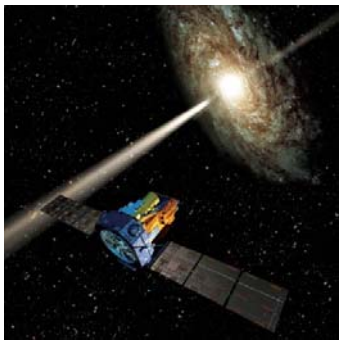
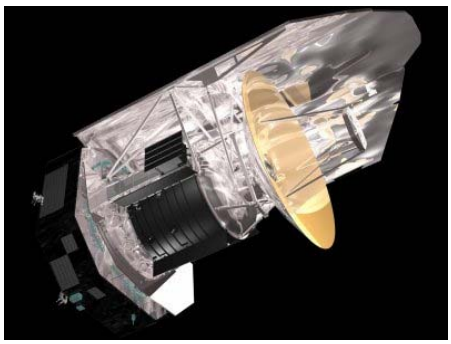

Figure 1-2: From left to right: XMM-Newton (ESA X-ray observatory), INTEGRAL (ESA gammy ray observatory), Herschel (ESA Infrared observatory)

2 Project Concept

The ESAC Trainee Project has been developing and recruiting young scientists for a number of years and takes place at the European Space Astronomy Centre (ESAC), near Madrid. Each young scientist participates in a trainee project which contributes to various astronomical satellite projects such as XMM-Newton, ISO, Integral, Gaia and the Virtual Observatory (VO). The duration of each project is between 3 to 6 months. To qualify to be an ESAC Trainee you must be a national of one of the ESA Member States or its cooperating states.

The trainees as of now have been from the following universities:

- Spain: Universidad Complutense de Madrid; Universidad Autónoma de Madrid; Universidad Politénica de Madrid; Universidad Autónoma de Barcelona; Universidad de La Laguna; Universidad de Valencia; Universidad de Vigo.
- Austria: Technische Universität Wien.
- France: Ecole Centrale de Nantes; Institut Supérieur de l'Aéronautique et de l'Espace, Toulouse; Observatoire de Paris; Universitè de Paris.
- Germany: Technical University of Aachen; University of Bonn; University of Erlangen-Nuremberg; University of Tübingen.
- Greece: Technical Educational Institute of Crete.
- Ireland: Trinity College Dublin; University College Dublin.
- Italy: Università degli Studi di Lecce; Università degli Studi di Torino; Università degli Studi Roma Tre
- Sweden: Institute of Technology, Linköping.
- The Netherlands: Universiteit Utrecht.
- United Kingdom: University College London; University of Leeds; University of Leicester; University of Warwick.

The project is supervised by tutors and comprised of students from the following areas:

- The pre-graduate program for Spanish students from the UCM, that every year allows students from the Madrid Complutense University to do an internship at ESAC and get the results credited for their university career. As of 2007, this also includes a similar scheme with the Madrid Autónoma University.
- The ESA internship trainee programme.
- Other universities are welcome to participate.

Each year the project is split into sub-projects that benefit from overlap in the techniques of data analysis and conceptual structure. However, it is assured that the projects do not depend on one another, to ensure that a situation does not arise in which failure to receive important input from a given sub-project could cause any other sub-project to fail.

To get the projects started, a "First definition" and the "First steps and goals" are defined by the tutor as an initial guideline. The "First definition" is then refined and extended by the trainee to a real project definition after the first few weeks. The "First steps and goals" are transformed into a "Timeline" for the project by the trainee, supervised by the tutor. This strategy allows the trainee to start from the outset on a well-defined project, which is highly important for projects on short time-scales. It also allows the trainee to redefine and structure the project after a short period of introduction and adjustment. The concept of a realistic timeline also allows room for contingencies. After successful completion of the work, a self-assessment and review enable the trainee to get a first impression of the structure of project work, and to develop skills for the future regarding projects set up on a similar basis

3 Projects

3.1 Epic pattern characteristics

ESAC supervisor(s): Norbert Schartel

XMM-Newton is a space-based X-ray astronomical observatory, launched in December 1999 with operations currently approved until 31 December 2012. The payload consists of three instruments provided by the scientific community, an X-ray camera (EPIC), a spectrometer (RGS) and an optical/UV monitor (OM). The XMM-Newton ground segment includes the Science Operations Centre (SOC) located at ESAC. The SOC has overall responsibility for mission planning, including community support and maintenance of the science archive. Together with the instrument teams, the SOC is responsible for instrument calibration and scientific monitoring and coordinates the Scientific Analysis Software development and maintenance in collaboration with the XMM-Newton Survey Science Centre consortium. The SOC is organized into Science Support and Instrument Operations Teams.

One of the main instruments on board of XMM-Newton, the EPIC camera consists of two MOS CCD cameras and one pn CCD camera. Each registered photon is recorded in one, two, or more pixels, creating the different so-called patterns. For spectral analysis, information on the incident photon is reconstructed based on the pattern geometry. For spectral analysis only events with certain pattern signatures are recommended for usage. This project proposes an analysis of the pattern behavior, considering the physical nature of the sources and background (flaring) events, and if possible to expand the currently available usable information.

Project duration: 3 months

Desirable expertise or programming language:

- Software skills are of an advantage.

3.2 XMM-Newton source catalogue

ESAC supervisor(s): Maria Santos-Lleo and Norbert Schartel

XMM-Newton is a space-based X-ray astronomical observatory, launched in December 1999 with operations currently approved until 31 December 2012. The payload consists of three instruments provided by the scientific community, an X-ray camera (EPIC), a spectrometer (RGS) and an optical/UV monitor (OM). The XMM-Newton ground segment includes the Science Operations Centre (SOC) located at ESAC. The SOC has overall responsibility for mission planning, including community support and maintenance of the science archive. Together with the instrument teams, the SOC is responsible for instrument calibration and scientific monitoring and coordinates the Scientific Analysis Software development and maintenance in collaboration with the XMM-Newton Survey Science Centre consortium. The SOC is organized into Science Support and Instrument Operations Teams.

Within the XMM-Newton project two catalogs are maintained: one listing X-ray sources and another one listing the UV/optical detections. The task of the applicant will be to cross-correlate both catalogs against know Active Galactic Nuclei (AGNs) and to search for elusive AGNs characterized through certain spectral energy distributions.

Project duration: 3 months

Desirable expertise or programming language:

- Software skills are of an advantage.

3.3 X-raying the gaseous environment of supermassive black holes

ESAC supervisor(s): Matteo Guainazzi, Ignacio de la Calle, Martin Stuhlinger (ESAC), Stefano Bianchi, Giorgio Matt (Universita' di Roma Tre), Kazushi Iwasawa (Universita' Bologna)

The goal of this project is the study of the iron emission line complex in a sample of heavily X-ray obscured Active Galactic Nuclei (AGN). AGN are among the most powerful objects in the universe. The origin of their fantastic energy output is believed to be accretion onto a supermassive (million to billion solar masses) black hole. The AGN radiation interacts with gas and dust in the galaxy core, producing characteristic X-ray spectral features such as fluorescent and/or recombination lines from elements with a widely varied degree of ionisation. Through careful modelling of these features, one can derive fundamental properties as to the location, geometrical distribution and physics (ionisation, density, temperature) of material in the nuclear environment. The proposed AGN sub-sample is particularly tailored to study the reprocessing of the AGN radiation by circumnuclear matter.

The project will be organised in the following steps:

- cross-correlation of published samples of Compton-thick (i.e., heavily obscured in X-rays) AGN with the whole archive of scientific XMM-Newton observations
- extraction of time-averaged spectra from the EPIC cameras on-board XMM-Newton
- merging of spectra of the same celestial source taken at different time
- spectral analysis of the iron emission line complex
- comparison of the observational results with the predictions of radiative transfer codes
- creation of a measurements database

A possible (but optional) extension of this project to the study of the FeI K-alpha fluorescent line spatial distribution in Chandra high-resolution X-ray images is envisaged for the second half of a 6 months stage.

Outcome: One scientific paper

Project duration: 3 to 6 months

Desirable expertise or programming language:

- Required: University course in electromagnetism
- Optimal: Good knowledge of at least one major programming language
- Optimal: Familiarity with the Unix/Linux operating systemIRAF

3.4 Neutron stars and black holes on the edge

ESAC supervisor(s): M. Diaz Trigo and A. Parmar

Aim: A low-mass X-ray binary is a system with either a neutron star or black hole accreting from a low-mass companion star via an accretion disk. About 10 of these systems show dips in their light curves recurrent at the orbital period of the system and share the property of being observed at high inclination. The observation angle makes the dippers particular interesting since a number of characteristics (e.g. complex spectral changes during the dips or occasional disappearance of dips) are observed which are not easily explained. The aim of this project is to analyse the X-ray data sets available for all the dipping sources observed with Suzaku and XMM-Newton which have not yet been published. The proposed data sets provide us with a unique opportunity to understand the complex relations between dips, variability of the source and reprocessing of emission combining the unique capabilities of Suzaku and XMM-Newton.

Project duration: 3 months or longer (depending on the number of sources analysed)

Desirable expertise or programming language:

- The analysis will be mainly done with SAS (XMM analysis software), shell scripts and IDL may be used to simplify tasks and produce outputs of the analysis.

3.5 Gallery of selected galactic supernova remnants

ESAC supervisor(s): Martin Stuhlinger, Ignacio de la Calle

If impressive X-ray images are to be presented, supernova remnants are on the top of the short list of the most suited sky objects. Especially in case of thermal origin of the X-rays, supernova remnants can show very different appearance dependent on how the images are generated. The successful candidate of this project will enter deeply into the X-ray analysis of XMM-Newton EPIC and RGS data for extended sources by the generation of images and spectra, including the identification of emission lines. The student will obtain a good overview on the characteristics of various types of extended X-ray sources.

Outcome: The XMM-Newton calibration team at ESAC selected a large set of observation for calibration purposes, building the ESAC cross-calibration archive, based on an automated data reduction and fitting tool. The goal of the project is the implementation of a double background correction method for extended sources into the automated data reduction. The minimum outcome (3 months) is a nice poster presenting images and spectra of selected galactic supernova remnants, to be used for XMM-Newton related public relations at ESAC, on the web and at X-ray astronomy conferences. The maximum outcome (6 months) could be a publication on comparisons of different double background correction methods based on a set of extended targets.

Project duration: 3 to 6 months

Desirable expertise or programming language:

- No special skills are required except the ability and will to learn.
- The project requires some programming in LINUX/UNIX based environment.

3.6 X-rays vanishing in the interstellar medium

ESAC supervisor(s): Maria Diaz Trigo & Andy Pollock

An X-ray astronomer's view of a favourite star, black hole or quasar is spoiled by photons that disappear while travelling through interstellar space. An encounter with a heavy atom or molecule can prove fatal. Nearly everyone's X-ray spectrum bears the chemical imprint of the intervening medium because different elements absorb different wavelengths. With the high resolution of the RGS, the quantum mechanics also become visible. The objective of this project is to gather the best RGS data to learn as much as possible about the physics and chemistry of this vanishing act.

Project duration: 3 months

Desirable expertise or programming language:

- Elementary atomic physics

3.7 Parallel 3D models of the flow in the colliding winds of binary systems of hot stars

ESAC supervisor(s): Andy Pollock & Rubén Alvarez

Strong winds flow away from the surfaces of hot stars driven by radiation pressure. Hot stars, both with strong winds, are often to be found in pairs orbiting one another in eccentric binary systems. This makes the flow of material more complicated and it becomes difficult to understand properly how the X-rays that are observed from such systems get emitted and absorbed when the geometry is changing all the time. In the recent past, sophisticated hydrodynamic simulation codes have been offered to the public that can be used to tackle such problems. These codes are parallelised to run on a grid and one called Athena-3D has been installed on the grid at ESAC. This challenging project, supervised jointly by an astronomer and a computer scientist, is designed for someone with a combination of interests in parallel computer simulations, plasma physics and MHD to get the code running on the ESAC grid to make models of the X-ray measurements of some well-known binary systems.

Project duration: 3 to 6 months

Desirable expertise or programming language:

- Experience in computer simulations.
- Interests in plasma physics and gas dynamics.

3.8 Analysis of Gravitational Microlensing events observed with the OSIRIS narrow angle camera on the Rosetta spacecraft

ESAC supervisor(s): Michael Küppers and Björn Grieger

Gravitational microlensing is the brightening of a star when a third object passes through the line between star and observer and acts as a gravitational lens. Microlensing is the only method of detecting very low mass stars and cool brown dwarfs that constitute much of the mass of the galactic disk. The light curve of a microlensing event depends on the mass of the lensing object and the geometry of the event. If an event is observed from two different locations separated by at least several tenth of an AU, the geometry can be constrained and better mass determinations are possible. That kind of observations was performed last year when the OSIRIS narrow angle camera on Rosetta observed microlensing events that were known from earth-based observations. The photometry of the events in the galactic bulge is complicated by the crowded start field. The task of the trainee is to perform the photometry of the events and to investigate methods of automization of the process. The project can potentially include the reduction of complementary earth-based observations.

Project duration: 6 months

Desirable expertise or programming language:

- Astronomical photometry, ideally crowded field photometry.
- Good programming skills in any language are essential. Knowledge of IDL is an asset.

3.9 Scheduling Optional Tasks in an Over-Constrained System of Dependent N-ary Resources

ESAC supervisor(s): David Frew and Harold Metselaar

The European Space Astronomy Centre (ESAC) is ESA's centre for space science. It is located in Villanueva de la Cañada, close to Madrid in Spain, and hosts the science operation centres (SOCs) for all ESA astronomy and planetary missions together with their scientific archives.

The Mission Independent Group (MIG) is elaborating a Science Operations Planning System (SOPS) to facilitate the SOCs in maximizing the scientific return for planetary missions. Science operations planning leads to complex planning and scheduling problems.

The core characteristics of these problems is the allocation of shared and limited resources (e.g. power budget, data storage, downlink time, science constraints, etc.) to competitive activities (observations/measurements by the different instruments onboard a satellite) over a given period of time, taking various dependencies and constraints between the activities into consideration.

The Project: The project will be divided in three parts. After getting familiar with the problem domain he/she will:

1. Together with the supervisor(s) and subject matter expert(s) decide on the scope.
2. Research possible approaches and perform a comparative study.
3. Implement a prototype.

Project duration: For this project to be completed satisfactorily, it is foreseen that a period of 6 months is needed.

Desirable expertise or programming language:

- The student shall be in the last year of a degree in Computers Engineering/Informatics, or Mathematics.
- He/she shall have affinity with algorithmics.
- Knowledge of Decision Theory and/or Artificial Intelligence in the area of planning and scheduling would be an advantage.
- The working language is English.

3.10 Study and Application of Superresolution Techniques to the Images from the OSIRIS cameras onboard Rosetta

ESAC supervisor(s): Jose Vázquez-García and M. Küppers

Background: **Rosetta** is an ESA mission that will study the comet **Churyumov-Gerasimenko**. One of the instruments on board the orbiter, the **OSIRIS** camera system, is made up of a wide-angle camera and a narrow-angle camera to obtain high-resolution images of the comet's nucleus and two asteroids (Steins and Lutetia).

One of the ways of improving the quality of the images taken by OSIRIS could be the increase of its resolution by 'artificial' means. **Superresolution** algorithms are a set of mathematical techniques to improve the resolution of a set of images when the physical characteristics of the acquisition sensor are fixed.

Description of the project: The trainee will have access to the OSIRIS image database, and will continue the research done in a previous stage. He/she shall:

- Study the state-of-the-art superresolution techniques, and its application to the OSIRIS images. The student shall take over the work from a previous stage, and concentrate two pre-selected algorithms, which will be tested with OSIRIS images of Mars and the Earth, taken during fast flybys of those planets in 2007.

- Propose a set of criteria under which a set of images in the OSIRIS database could be used together as input to the algorithm above.

Project duration: For this project to be satisfactorily completed, it is foreseen that 6 months will be needed.

Desirable expertise or programming language:

- The student shall be in the last years of a degree in Engineering, Physics or Mathematics.
- He/she shall have strong foundations in Mathematics and Image Processing.
- Knowledge of the IDL programming language is mandatory.

3.11 Automated Analysis of Large Planetary Datasets

ESAC supervisor(s): Albrecht Schmidt and Erwan Treguier

Recent advances in algorithms and computing technology have made it possible to efficiently factor a collection of spectra into sources and abundances under linearity and non-negativity constraints. The aim of this internship is to finish porting a Matlab-based infrastructure, develop at Ecole Central de Nantes and ESAC, to an open-source tool set. Also, the student will have to compare different factorisation algorithms.

The context of the work is the large-scale analysis of hyperspectral images taken during planetary mission, such as by Mars Express' OMEGA instrument or Rosetta's OSIRIS. Algorithmically, a hyperspectral image, interpreted as a matrix that relates wavelengths to pixels, has to be factored into two matrices: a small source matrix, representing the signals with which the complete spectrogram is approximated, and a large matrix of abundances which represents the degree to which each source is present at a particular location.

The ultimate aim is to automate the analysis of the data as much as possible and apply it to one of ESA's archived science data, both as a test case and on the way towards producing science.

Project duration: 6 months

Desirable expertise or programming language:

- The student should have a basic understanding of spectroscopy and programming languages like Matlab and Python.

3.12 Database development for science data of the CIRS infrared spectrometer on-board the Cassini Spacecraft

ESAC supervisor(s): N. Altobelli

The Cassini mission is a joint ESA/NASA mission in the Saturnian system. An import goal of the mission is the characterization of Saturn's ring system. During the past 5 years, the Composite Infrared Spectrometer (CIRS) instrument has been observing the ring in the thermal infrared (far and mid IR), retrieving spatially resolved temperature and field-of-view volume filling factor measurements of the ring. Over 2.5 millions individual spectra have been obtained so far, each of them with its own observation geometry. Variations of the measured temperature and volume filling factor with the geometry reveal physical properties of the rings.

The data of the far IR channel are currently stored in a MySql database and a simple interface exists with the IDL programming language for efficient data analysis. It is planned to facilitate the data access by providing a web-based interface to the data.

The goal of this internship would therefore consist of the following:

- build a web-based interface to the existing far-IR database
- design a database for the mid-IR data
- enhance the optimization of the databases in order to ensure fast data queries
- if time allows, enhance the existing MySql-IDL wrapper and build a MySql-Matlab interface

Project duration: 6 months

Desirable expertise or programming language:

- Good programming skills under various environments (Unix/Windows)
- Familiar with MySql databases and web-interface (PHP)

3.13 Geometry Analysis for Planetary Science Planning

ESAC supervisor(s): Miguel Almeida and Raymond Hoofs

In planetary missions the geometry of the observations is of key importance. The observations can be characterized by the Sun position, all types of positions and attitudes of the spacecraft in relation to the planet, or even star positions. Different payloads pointing requirements are not always compatible and decisions have to be made on which experiments take priority. Therefore the full knowledge of a given observation is extremely important in the decision making process. In this project, the student shall compile a comprehensive list of valuable observations and their geometries and use IDL and SPICE (planetary data information system) to analyse them. The output shall be a library of IDL functions that will give fast access to the information.

Project duration: 6 months

Desirable expertise or programming language:

- Good geometry skills, algorithm writing and some programming skills
- Knowledge of IDL and/or SPICE would be an asset

3.14 Test and optimisation of a setup to record meteors as a tracer of cometary properties

ESAC supervisor(s): D. Koschny and J. Mc Auliffe

ESA/RSSD's Meteor Research Group (MRG), active from both ESTEC and ESAC, has been involved in studying meteors since >10 years. Meteors are produced when small dust particles from comets and asteroids, called meteoroids, enter the Earth's atmosphere. The MRG is currently setting up two observing stations in the Canary Islands, see e.g. http://www.rssd.esa.int/index.php?project=METEOR&page=cidstamp .

Image-intensified video cameras are used to observe the same location in the Earth's atmosphere from two different directions. From these stereo observations, the path of the meteoroid in the sky and thus its orbit around the sun can be reconstructed. The change in brightness of the meteor will be recorded. One of the cameras will be equipped with a transmission grating to obtain spectra of the meteoroid. These are needed to study the chemical composition of the meteoroid. With this information, the physical and chemical properties of the parent body can be constrained.

The trainee will have access to the hardware and software which has already been developed in the frame of this project. He/she will be supporting the test and optimisation of the setup.

Project duration: 3+ months

Desirable expertise or programming language:

- Setting up observing stations, testing them

3.15 Pulse profile evolution in GX 1+4

ESAC supervisor(s): Peter Kretschmar and Erik Kuulkers

GX 1+4 is an accreting X-ray pulsar close to the Galactic Centre region. It has been monitored regularly over the past years by the Integral Galactic Bulge Monitoring programme (PI E. Kuulkers). In a previous trainee project and subsequent masters' thesis its period evolution has been studied in detail and the results are being published (A. Gonzalez-Galan et al., in prep.).

As a side effect of the period evolution study, significant variations of the source's pulse profile (light curve folded with pulse period) have been observed, but not yet systematically studied. The study of these variations and possible correlation with source luminosity changes is the core of the new project. A significant number of profiles have been extracted already, but newer Integral data will need to be analysed as well. In the long run, the results of this project shall be included in another scientific publication.

Project duration: 3 months. This should be sufficient for a classification of different profile shapes and a systematic search for correlations.

Desirable expertise or programming language:

- Linux command line environment
- Knowledge of IDL
- Knowledge of accreting X-ray pulsars

3.16 Simplified access to INTEGRAL data, data products and visualization tools

ESAC supervisor(s): Marion Cadolle Bel and Silvia de Castro

The INTEGRAL Science Operations Centre (ISOC) provides a number of services to the gamma-ray community. Amongst these are the INTEGRAL Observation Schedule Application (IOSA) and the ISOC Science Data Archive (ISDA). The IOSA allows astronomers to browse details of INTEGRAL observations, both in the past and in the near

future. The interface is clear and the system is heavily used by the whole INTEGRAL community. The ISDA meanwhile provides users with a powerful and flexible interface to select and download data and perform some data visualisation and analysis. The ISDA includes a VIRTUAL Observatory (VO) interface allowing external VO applications to access the data.

This project aims at integrating the IOSA and ISDA such that the IOSA can be used to download data from INTEGRAL observations and to launch the tools for visualizing INTEGRAL data. All communication between the two packages will be via the existing VO interface in the ISDA. The aim is not to reproduce the powerful functionality of the ISDA, but to provide a greatly simplified view of the INTEGRAL data in an environment which is already familiar to the majority of the gamma-ray community. Users of the IOSA should have the option of launching the full ISDA browser at any stage. By this we will not only increase the accessibility of INTEGRAL data but also increase the awareness of the ISDA. The selected candidate will have the opportunity to work in a high technological environment, learn about the newest Java technologies (Design Patterns, SOA, Servlets, JSP, JUnit testing) and use various power tools (Maven, Subversion, Hibernate).

Project duration: 3 months

Desirable expertise or programming language:

- Good knowledge of the Java programming language is required.
- Some experience with databases, Servlets and JSP is considered to be an advantage.

3.17 Study of the properties of a selected sample of X-ray bursters with INTEGRAL

ESAC supervisor(s): Celia Sanchez

Scientific Background: Type I X-ray bursts are thermonuclear explosions on the surface of a weakly magnetized accreting neutron star. They happen in Low-Mass X-ray Binary (LMXB) systems where the mass donor is typically an evolved star. Observationally, X-ray bursts can show a large variety in profiles, but generally they exhibit a fast rise and a longer, usually exponential, decay. Burst rise times vary from less than a second to ~10 s, and decay times are in the range of seconds to minutes. The time elapsed between successive bursts can be regular or irregular, but typically on time scales of hours to days. Bursts radiate X-ray spectra with black body shapes and temperatures up to roughly 3 keV, that cool during burst decay, while the emitting region size remains constant.

Aims: We have developed an IDL code to search for X-ray burst in the light curves of X-ray bursters detected with INTEGRAL. The goal of this project is to apply these routines, and eventually improve them, to the available data in the INTEGRAL archive, in order to study the properties of one (or various, if there is time) X-ray burster, selected on the basis of its scientific interest. The idea is to characterize the properties of the bursts detected, in terms of energy release, recurrence time and duration, and to compare them with the overall source properties, especially with the accretion rate onto the neutron star.

Project duration: 3 to 6 months

Desirable expertise or programming language:

- Knowledge of IDL would be an advantage.

3.18 Weighing the densest stars in the universe

ESAC supervisor(s): Erik Kuulkers

Neutron stars are built up of matter at the highest densities possible in the universe, not reproducible on earth. Matter in these conditions can thus only be probed through astrophysical observations. One of the holy grails of (X-ray) astronomy is to measure the equations of state of a neutron star, i.e., how does the mass of the neutron star relate to its radius. Up to now we have not measured directly both the mass and radius. For one neutron star multiple phenomena have been observed that can in principle be used to uniquely determine the equation of state. This has already been applied, but

verification is needed, and a more observational and statistical approach is desirable. Also, in the meantime more information has become available, so one can update and/or refine the resulting parameters.

Project duration: 3 to 6 months

Desirable expertise or programming language:

- A mathematical minded physicist is needed, with good knowledge of statistics.
- A good knowledge of a programming language is desirable.

3.19 Study of extended far-infrared diffuse emission structure in star forming regions based on Herschel large-scale maps

ESAC supervisor(s): Roland Vavrek

Herschel imaging photometry provides the highest ever spatial resolution imaging in the far-infrared. Large-scale maps of star forming regions show emission of the diffuse background with details which have never been characterised compared to lower-resolution experiments flown in the past. The goal of the project is to define a suitable statistical descriptor of complexity based on multiresolution image analysis techniques. Data will be available from the public domain of the Herschel Science Archive and from Guaranteed Time proposals of the Herschel Science Centre.

Project duration: 6 months

Desirable expertise or programming language:

- Experience with at least one high-level data interpreter language (for instance IDL, Matlab, Mathematica) is an asset.
- Experience with scripting languages (Python, Jython) and Java is an advantage.

3.20 Gaia. Young stars spectroscopic library

ESAC supervisor(s): Alcione Mora and Ralf Kohley

Gaia is a Cornerstone mission of the European Space Agency, with a launch date scheduled for spring 2012. It will produce a three-dimensional map of the positions and proper motions of one billion stars in the Galaxy with unprecedented astrometric precision. Gaia will produce breakthrough advances in many fields. A few examples are the structure and dynamics of the Galaxy, star formation and evolution and exoplanet detection. More information on the science cases, technological challenges and mission planning can be found in the Gaia information sheets:

http://www.rssd.esa.int/index.php?project=GAIA&page=Info_sheets_overview

Gaia is equipped with the RVS, an intermediate resolution (R ~ 10000) spectrometer that will provide radial velocities for the brighter stars. The wavelength range selected (847-874 nm) contains the CaII IR triplet, several Paschen lines and many metallic lines. That information, combined with the distances and photometric data also given by Gaia, will provide accurate physical stellar parameters (e.g. Temperature, gravity, absolute luminosity, radii, rotation speed, etc.).

Gaia will obtain RVS spectra of pre-main sequence stars down to solar masses for the whole extension of the Gould Belt, which encompasses the nearest star forming regions up to a distance of ~500 pc. The evolution of intermediate mass stars in the solar neighbourhood could be traced from a few Myr down to the ZAMS using a complete and unbiased survey.

In this context, it is essential to study the behaviour of the different lines in the RVS range for young stars. Variability, emission and circumstellar absorption are typical phenomena that could render the lines useless for physical parameters determination. We propose to build an intermediate resolution spectral library of PMS stars using archive data. The data would be reduced (if required) and resampled to the range and resolution provided by Gaia. Observed spectra would be compared to synthetic templates to identify stable photospheric lines. The most useful lines for physical parameter determination would be identified in function of the spectral type and rotational velocity.

The trainee will gain valuable experience in the following fields:

- Deep knowledge of the Gaia mission
- Operation of the Gaia Radial Velocity Spectrometer
- Stellar parameters determination
- Archive data
- Data reduction
- Synthetic spectra

Project duration: 3 months

Desirable expertise or programming language:

- Astronomy
- Unix
- Data reduction (e.g. IRAF, IDL)

3.21 Lithium and other chemical abundances in open clusters

ESAC supervisor(s): David Barrado (LAEX-CAB)

Open clusters are Rosetta stones which have been used to decipher key stellar properties, since they include a population of stars of the same age and metallicity. On the other hand, lithium is an element which can be used as a tracer of mixing mechanisms in the stellar interior, or as an age chronometer. We have multifiber high resolution spectra of a large number of cluster members in several association ranging from Alpha Per (90 Myr) to Praesepe (600 Myr), and including the Pleiades and M35, among others. These data can be used to derive radial and rotational velocities, activity rates, lithium abundances (and other elements, such as other alkali and iron) and to study these properties in the context of their dependence on mass and age. This study is of extreme importance due to the Gaia satellite, the ESA astrometric mission, which will require this type of data to properly interpret the astrometric information.

Project duration: 6 months

Desirable expertise or programming language:

- Background in astrophysics, with IRAF and/or MIDAS.

3.22 Very high energy gamma-ray spectra in the Virtual Observatory

ESAC supervisor(s): Deborah Baines, Ignacio de la Calle, Aitor Ibarra (ESAC), Jose Luis Contreras (Universidad Complutense de Madrid)

Supernova, Active Galaxies harbouring supermassive black holes and Gamma-ray Bursts are amongst the most violent events in the Universe. Broadband spectral studies, covering the whole electromagnetic spectra from radio to very high energy gamma-rays., are the only means to ultimately understand the mechanisms of acceleration of ultra-relativistic particles in these objects.

The goal of this project is firstly to publish high energy gamma-ray spectra from the MAGIC telescopes into the Virtual Observatory (VO) so that it can benefit from data at other wavelengths while at the same time become available to a wider range of researchers around the world. MAGIC (http://magic.mppmu.mpg.de/) is an Imaging Atmospheric Cherenkov Telescope (IACT) located at El Roque de Los Muchachos (La Palma), used for the detection of high energy gamma-rays. The Virtual Observatory is an international astronomical community-based initiative which aims to allow global electronic access to the available astronomical data archives of space and ground-based observatories, and sky survey databases. It also aims to enable data analysis techniques through a coordinating entity that will provide common standards and state-of-the-art analysis tools.

The publication of MAGIC spectra into the VO will extend the wavelength/energy regime of spectra in the VO by a factor of 10^9, from a few KeVs (X-rays) to TeVs (high energy gamma-rays) and will be the first ground-based gamma-ray spectra to appear in the VO. This will allow, in the second phase of the project, to build the Spectral Energy Distribution (SED), covering from radio to high energy gamma-ray data, of the TeV blazar Mrk421, the most violent of the TeV active galaxies known to date. The project aims at addressing the long and short term variability of the spectral properties, with the ultimate goal of understanding how particles are accelerated in these objects to relativistic velocities. Lastly, it is expected that the knowledge gained will set the foundations for the publication in the VO of data from the future Cherenkov Telescope Array (www.cta-observatory.org), a European effort to build the first high energy ground-based observatory in the world open to the whole scientific community when it becomes operational around 2015.

Outcome: One conference paper, and depending on the results, one scientific paper.

Project duration: 3 to 6 months

Desirable expertise or programming language:

- Required: Astrophysics university courses.
- Optimal: Good knowledge of at least one major programming language (especially Java).
- Optimal: Familiarity with the Unix/Linux operating system.

4 More Information

To apply please complete the online application form, filling out your details, indicating which projects you want to apply for and uploading your CV (in English), at the following webpage:
http://www.sciops.esa.int/index.php?project=ESACTRAINEES&page=Training%20Opportunities

The application deadline is 5th February 2010.

You are welcome to contact D. Baines for details at:

Deborah.Baines@sciops.esa.int