**Introduction**

This issue represents a milestone for the CAAUL Gazette – it is the first issue of its second year of existence! The Editorial Team would like to thank the various contributors over the last year to help get this Gazette underway. It is very much dedicated to publicizing the various events, outreach activities and research carried out by members of the Centre, and aimed at the international scientific community.

One major event that the Centre is organizing is this year’s ENAA – the National Meeting of Astronomy and Astrophysics – which is Portugal’s showcase for the exciting research carried out in the various universities and research institutes throughout Portugal and beyond.

We hope you enjoy this issue – especially the description of the Diamond in the Sky AstroConundrum by João Lin Yun and the RedShift article on Optical Navigation by José Manuel Rebordão – and we look forward to your contributions to future issues!

**Director's Comment**

One would say that two-thirds of the dynamism of a research institution comes from the youngest one third of researchers (including students). These are the restless ones that want to achieve something, that set their goals high, that want to show they can ride the research wave and bring value to both their institution and themselves (usually it is further along the road that this mutualism breaks down and the individual can break apart from the goals of its research environment). It is unfortunate that so many institutions don’t pay enough attention to these resources and, by design or by chance, don’t opt for an active enrollment strategy for its ranks. At CAAUL, we have been quite active over the last few years in recruiting new postdoctoral fellows that can strengthen our research groups and the Institution as a whole. We have been less successful in gathering a similar group of postgraduate students, mostly due to large tuition fees, poor advertisement and limited funding for scholarships. Recently, however, we managed to break away from some of these restraints. When a new funding scheme by the national funding agency (FCT) appeared, we knew that it was a chance not to be missed. Space Sciences is, after all, currently recognized as one of the scientific topics in Portugal with the most international impact. So, as part of the Consortium for Research in Astronomy and Astrophysics (which currently joins together CAAUL and the Center for Astrophysics of the University of Porto); we started the first Doctoral Network in Space Sciences which, I’m glad to say, was successful (with a particularly good appraisal by the international panel assembled for its review).

So, we are now faced with the prospect of a new phase of growth and consolidation of Astronomy in Portugal, and will be start looking internationally for bright students to come here for their PhD studies, in collaboration with researchers in ESO and ESA. And, with that energetic and enthusiastic workforce, I am certain we will see even more and better results from our research activity.

**News from CAAUL**

**XXIII National Meeting of Astronomy and Astrophysics**

It is our pleasure to announce the XXIII edition of the Encontro Nacional de Astronomia e Astrofísica (ENAA) that will be held in Lisbon at the Faculdade de Ciências da Universidade de Lisboa on the 18th and 19th of July 2013, organized by the Centro de Astronomia e Astrofísica da Universidade de Lisboa (CAAUL) in collaboration with the Sociedade Portuguesa de Astronomia (SPA). The aim of ENAA meetings is to promote and strengthen the interactions among the members of the Portuguese community of Astronomy and Astrophysics, to assess the strategic goals of the community for the future, to discuss the involvement of Portugal in international projects and organizations, and define opportunities in education and public outreach.

The XXIII ENAA intends to contribute to the effort to gather the restless ones that want to achieve something, that set their goals high, that want to show they can ride the research wave and bring value to both their institution and themselves (usually it is further along the road that this mutualism breaks down and the individual can break apart from the goals of its research environment). It is unfortunate that so many institutions don’t pay enough attention to these resources and, by design or by chance, don’t opt for an active enrollment strategy for its ranks. At CAAUL, we have been quite active over the last few years in recruiting new postdoctoral fellows that can strengthen our research groups and the Institution as a whole. We have been less successful in gathering a similar group of postgraduate students, mostly due to large tuition fees, poor advertisement and limited funding for scholarships. Recently, however, we managed to break away from some of these restraints. When a new funding scheme by the national funding agency (FCT) appeared, we knew that it was a chance not to be missed. Space Sciences is, after all, currently recognized as one of the scientific topics in Portugal with the most international impact. So, as part of the Consortium for Research in Astronomy and Astrophysics (which currently joins together CAAUL and the Center for Astrophysics of the University of Porto); we started the first Doctoral Network in Space Sciences which, I’m glad to say, was successful (with a particularly good appraisal by the international panel assembled for its review).

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This newsletter is available at [http://www.caaul.oal.ul.pt/gazette](http://www.caaul.oal.ul.pt/gazette)

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Upcoming Events

CAAUL’s activity is present in major scientific events throughout the world. This section will keep you informed about up and coming events that CAAUL organizes or participates in. You will find here notices of national and international conferences with the presence of CAAUL’s researchers as well as major outreach events, often organized by the Astronomical Observatory of Lisbon and with the support of CAAUL. Relevant funding opportunities, when available, will also be advertised here.

Conferences/Workshops:

- 18 July to 19 July 2013: XXIII Encontro Nacional de Astronomia e Astrofísica (XXIII ENAA), Faculty of Sciences, U. Lisbon, Portugal
- 22 July to 26 July 2013: VIII Iberoamerican Conference on Optics, Faculty of Sciences, U. Porto, Portugal
- 2 September to 6 September 2013: COSMO13, Centre for Theoretical Cosmology, U. Cambridge, UK
- 16 September to 18 September 2013: Modified Gravity Theories: Beyond Einstein’s Legacy, Faculty of Sciences, U. Lisbon, Portugal
- 14 October to 18 October 2013: Communicating Astronomy with the Public 2013 (CAP2013), Warsaw, Poland
- 19 November to 20 November 2013: ALMA Community Days 2013: Preparing for Cycle 2, ESO Garching, Germany

Outreach:

Awesome Universe Exhibition

This exhibition, that celebrates the 50th anniversary of the European Southern Observatory, shows the Cosmos captured in ESO’s various observatories, located in some of the most inhospitable places on Earth. After being on display at the National Museum of Natural History and Science of the University of Lisbon, it will be on display at the the Calouste Gulbenkian Planetarium from early July. Associated with the exhibition, CAAUL and the Astronomical Observatory of Lisbon organize 3 events entitled “Living an Awesome Universe”, taking place at the Planetarium. Each event consists of a public talk and guided observations of the night sky.

João Retrê

the Portuguese astronomical community and foster the synergy between national research institutions. The public session of this edition will take place on the 19th of July at the Observatorio Astronomico de Lisboa and it will include a visit to the Observatory, the presentation of an outreach talk, and a night sky observing session.

Information about the XXIII ENAA can be found at

enaa2013.oal.ul.pt

Arrivals and Departures

Ciro Pappalardo recently secured a post-doctoral fellowship for the project “Dust as a probe of galactic environments”. He obtained his Ph.D. at the University of Strasbourg, and he worked as a Post-Doc in the Observatory of Arcetri, in Florence. Now he will investigate how the dust and gas distributions in a cluster galaxy are affected by the environment in which they inhabit. This will be made through the analysis of Herschel data from the two closest clusters of galaxies: Virgo and Fornax. The second goal of his project is to detect and study the properties of background galaxies as observed in the direction of both clusters.

Recent Publications

AstroConundrum

A Diamond in the Sky!

The presence of nebular emission surrounding candidate young stellar objects (YSOs) detected in near-infrared images of high extinguished molecular cloud cores is taken as a clear sign of the young stellar nature of the objects.

The nebular emission seen is commonly associated with the phenomenon of mass ejection from young stars. This constitutes one of the major signposts of star formation in a molecular cloud occurring simultaneously with the accretion of material from the surroundings of the star. The ejection of mass may be detected in the form of more or less collimated high-velocity winds, jets, and molecular outflows. The flow of gas ejected from the vicinity of the forming star results in the entrainment of ambient gas and the creation of cavities in the surrounding envelope and molecular cloud.

The presence of these cavities allows radiation from embedded YSOs to escape via scattering off the walls of the cavities. Thus, the morphologies of the near-infrared nebulosities trace the walls of cavities excavated by the stellar jets and outflows. In other cases, extended emission represents shocked gas at the location where the jets impact the ambient interstellar medium creating Herbig-Haro objects which are rich in (spectral) emission lines, seen in the optical, or in the near-infrared.

Finally, in some other cases, the presence of extended emission is due to binary (or multiple) star formation, with the presence of more or less extended nebulosity involving the multiple young stellar system. In this case, the nebulae represent circumstellar and/or circumbinary structures whose evolution form multiple systems.

In the course of my studies on discovery of new YSOs, I came across the IRAS source IRAS 06468-0325 which is an odd-looking object! It is located in the outer Galaxy close to the Galactic plane in the direction of Monoceros.

What makes this source rather striking is its very unusual and enigmatic morphology: that of a diamond-ring, that is, a ring or torus with a bright source overlapping the edge of it (not inside it). As the figure shows, the ring is quite sharp and does not seem to follow any of the models of nebular emission from associated star formation regions or sources.

In order to understand the nature of this source and what causes the morphological structures seen, we performed an investigation of IRAS-06468-0325.

We collected near-infrared JHKs-band images, millimeter CO spectra, low-resolution, long-slit K-band spectra, and L'-band images. Several conclusions could be reached:

- The object is an extended source composed of a bright, relatively point-like component connected to a ring or torus of extended nebular emission with sharp edges. In other words, the near-infrared counterpart of IRAS-06468-0325 has the appearance of a diamond ring.
- The ring is not uniform in brightness. The brightest part (here designated by ‘spot’) appears as a region located at the other end of the diameter connecting the diamond and the centre of the ring.
- The diamond and the spot are separated by a projected angular distance of about 3° which is also the approximate angular diameter of the ring.
- The diamond itself is not totally round and could be composed of a binary. However, the deviation from roundness is along the direction of the ring, hampering the possibility of distinguishing whether it is caused by the presence of a close companion or by contamination from ring emission.
- On the other hand, the spot does not correspond to the presence of a companion located at the brightest part of the ring. The spot is elongated following the ring and its FWHM (2.9°) is much larger than the typical FWHM (0.44°) of the point sources in the image.
- The CO lines are moderately bright and appear at the LSR velocity of about 30.5 km s⁻¹. They confirm the presence of molecular material seen towards the source. If this molecular material is associated to the source, it suggests that the diamond-ring is a Galactic source.

- The CO lines are irregular and non-Gaussian, with possible self-absorption. This fact may argue in favour either of rotation of the presence of turbulent gas motions (intermittent massive gas ejections) shocks?). However, there is no clear sign of a regular quiescent outflow (CO wings).
- Assuming a Galactic rotation curve that is essentially flat beyond the solar circle, and a Galactocentric distance to the Sun of 8.5 kpc, a kinematic distance of about 3 kpc to the source of the millimetre emission is derived. At this distance, the radius of the ring corresponds to about 4500 A.U. This is quite large compared to typical sizes of circumstellar regions in young stars.
- The diamond is clearly a red source. Its colours are compatible with a Class I YSO.
- The ring has a bluer colour, suggesting the possibility of being composed by scattered light. This structure may represent scattered light from a cavity in the circumstellar envelope of the “diamond”. However, the ring is quite sharp and does not seem to follow any of the models of near-infrared nebular emission from single protostellar envelopes with cavities excavated by stellar winds, jets and outflows.
- More likely the ring could be due to a circumbinary structure similar to others known (such as around GG Tau).
- With the current available data, it is not possible to state with certainty what kind of YSO, and in which stage, this source is.

Given the rare morphological appearance of the source, other non young stellar objects cannot be ruled out from the observational data available. Thus, if it is a Galactic source, we could be in the presence of a post-main-sequence source such as planetary nebulae. In fact, this class of objects is known to produce exquisite nebulae with symmetrical shapes. However, again none of the models or images of planetary nebulae fit the shape of this source with the diamond overlapping the border of the ring. Furthermore, should this source be a post-main-sequence object, the relative brightnesses and colours of the diamond and the ring and the relatively large extinction (invisible in most of the optical wavelengths) would remain to be explained.

The nature of this enigmatic object remains unknown.

João Lin Yun
RedShift

Optical Navigation – A Key Technology for Scientific Space Exploration

Autonomous Navigation (AN) is one of the key technologies of CAAUL researchers, based on intense ESA activity in the last 10 years. CAAUL focus on Optical Navigation (ON) one of the most relevant technologies for AN.

AN is required for deep space navigation, rendezvous between spacecrafts (S/C), terrain-relative navigation, autonomous landing in planets and asteroids, planet flyby and S/C relative navigation to ensure strict relative positions and orientations. AN is mandatory whenever there is no time to validate navigation decisions in the Earth. Using ON, known objects with known and reliable ephemerides are used as beacons, enabling the navigation system to accurately locate the S/C in space and plan subsequent maneuvers to accomplish the scientific mission. In this context, beacons are stars, planets, asteroids and even comets.

ON can be active or passive. Passive ON is based on passive imagers, active ON requires light sources, for example, LEDs or LIDARS. Image-based ON is based on 2D camera (V or NIR), which became space qualified and can be purchased as OSM subsystems, endowed with their own computing capability. There is no short supply of lenses. Sensor (CCD or CMOS) number of elements and dimensions, together with optical focal lens determine key operational parameters, such as FOV, angular resolution and sensitivities. Cameras typically provide Line-Of-Sight (LOS) estimates to the Guidance, Navigation and Control (GNC) system, which combines such estimates with the output of other sensors, implements filters and generates the best possible estimation for the actual orientation and position of the S/C. LIDARS are very good candidates for autonomous landing and may be irreplaceable whenever the surface topography is not accurately known; contrary to passive cameras, ESA is still in short supply of space qualified LIDARS for navigation, which must be small and should not demand too much power. LIDARS also require large computing capabilities, because the position and orientation of the S/C cannot be considered stable during the acquisition of one complete LIDAR frame; therefore, linear and angular velocities and accelerations must be recomputed several times to update kinematics parameters of previous frames in order to improve terrain knowledge. LIDARS have variable resolution and variable SNR, and power is obviously one big concern. New configurations are under development to overcome drawbacks for landing missions.

There are other important active configurations. For example, in S/C formation flying, some S/C may carry light beacons (either LEDs or lasers) which facilitate their detection by cameras located on chaser S/C’s – which usually navigate in order to perform rendezvous with the target mires-carrying S/C’s. Alternatively, target S/C may carry retro-reflectors, the active source being located in the chaser. Active sources improve SNR and system sensitivity, although they cannot overcome one key problem in rendezvous: direct solar illumination which strongly degrades system performances. Rendezvous in eclipse is the apparent solution but too many missions cannot comply with eclipse conditions, even for small periods. Direct solar illumination is, anyhow, a serious problem for any type of ON: reduces contrasts, creates stray-light problems, constrains exposures through saturation effects, generates spectral diversity issues, etc.

ON always requires image processing (IP) with its peculiar computer power needs - in principle, boundless. IP design is far from trivial for ON because there are many IP modes (not necessarily synchronized with navigation modes) associated with different geometric configurations between the camera and the beacons. Most important, there are transition modes, in which IP performances are unstable. In order to understand mode definitions, it must be taken into account that, in general, beacons can be point-like or extended. For point-like beacons, IP extracts LOS to the beacon’s center of brightness (COB), which is the unique estimator of the center of mass (CMD). Very faint beacons require large exposures - and their image can therefore be blurred – or many independent images to be superimposed using time-integration methods which require intensive IP but allow detection, say, of magnitude 13 beacons.

Limb is extracted from extended beacons images; the limb is the apparent line separating it area from deep space. There is a second important line, the terminator, which separates the lit and shadowed areas; it is unfortunate that both limb and terminator cannot be used: in fact, although both require apriori knowledge of the 3D shape of the beacon, the image contrast around the terminator is poor and therefore estimations have large errors. In any case, the estimated limb location and the known beacon shape do enable COM’s estimation, mandatory for relative navigation. Unfortunately few bodies are accurately known in 3D; 3D mapping requires previous missions, or a number of orbits, mappers and intensive computing power – which typically space agencies are not willing to make available easily. In most of the envisaged cases, mission-accepted beacons are therefore constrained to be spherical. Extended beacons have their own set of problems. As range decreases and beacon size increases: 1. exposures must be smaller and therefore background stars are no longer visible simultaneously, inhibiting altitude determination; 2. the angular size of the beacon exceeds camera FOV, therefore splitting the limb into pieces – its radius of curvature increases and COM estimation becomes problematic. In the transition between point-like and extended beacon modes, IP has a problem: angular resolution is not sufficient to analyze the limb and solar illumination phase degrades the use of COB as a good COM estimator. Alternatives do exist, always quite demanding in terms of (un)available on-board computer resources or needs of additional information.

IP is therefore the subject of demanding system tradeoffs, which have somehow restricted ON in the past. Nevertheless, there are no real alternatives to ON for deep space missions, and technology will inevitably make tradeoffs more sympathetic to ON. What is typically requested to the system? Two co-aligned cameras to cope with very different beacons angular size – technically feasible but creating problems in terms of volume, mass and computer requirements; zoom lenses to cope with dramatically different situations; zoom technology is not yet available for space; plenty of computer resources to use state-of-the-art IP methods; the evolution of space qualified cameras is slow and very often computers are shared between different S/C subsystems; optimal location of camera in the S/C: heat shields and communication antennas may create unexpected limitations; redundant altitude determination instruments in order to reduce the number of problems to solve by the ON camera: not always an option for system engineers.

The race between ESA and NASA is active and NASA has been leading, having already flown several AN & ON missions and having therefore accumulated relevant experience.

José Manuel Rebordão

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