

The CAAUL Gazette

The International Newsletter of the Centre for Astronomy and Astrophysics of the University of Lisbon



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Introduction

This issue coincides with a turning point for CAAUL and for Portuguese astronomers and astrophysicists in general.

In July, CAAUL organised the 23rd national meeting for astronomy and astrophysics (XXIII ENAA), the showcase for the exciting research carried out in the various universities and institutes throughout Portugal and beyond, research that is proving more and more difficult to pursue given the straightened times we live in. Results were presented in a diverse range of areas including planetary systems, stellar properties, stellar evolution, the Milky Way galaxy, extra-galactic astrophysics, cosmology, astroparticle physics – see below a brief report by Ismael Tereno and Elvira Leonardo.

This meeting could be considered a *turning point* for CAAUL; it is the last ENAA CAAUL will be organising before becoming part of, together with the Centro de Astrofísica da Universidade do Porto (CAUP), the new Institute of Astrophysics and Space Sciences, currently being proposed to the National

funding agency. Certainly, winds of change are blowing through the astronomical and astrophysical community. As Érico Veríssimo suggested: “Quando os ventos de mudança sopram, umas pessoas levantam barreiras, outras constroem moinhos de vento” (“When the winds of change blow, some people build walls, others build windmills”). Let us hope a bright new future is ahead for CAAUL and for Portuguese astronomers and astrophysicists.

Also presented in this issue is an article about Kepler and ‘the irreducible and obstinate facts’ written by Mariana Valente, and a personal view on the importance of the inclusion of planetary science in a higher educational syllabus, by João Corte-Real.

We look forward to your contributions to future issues!

David Berry, General Editor

Director's Comment

Research takes time. Research takes money. Is it worth it? I would say it cannot be any other way. Questioning what is around us, trying to understand our place in the Universe is not just a musing of idle minds. It is part of human nature, it is what has kept us alive for so long and what will keep us alive in case of future need. Like breathing, one needs to ask, to question, to search, to discover, and the true return value will not even ever be measurable (certainly not on time-scales comparable to those of any countries' governments). So, funding for science will always be a sensitive topic and, in particular in these days of economic concerns, be particularly well scrutinized and increasingly hard to obtain. The Center is currently going through a particularly detailed exercise that will dictate its funding for

the 2015-2020 period. We are confident in our adopted strategy, a strategy that, we believe, will strengthen the international capability of the Portuguese research in Astrophysics and Space Sciences. By building an even stronger environment for our researchers, we aim to increase our reach and achieve even more, ask more, understand more... For the next few months we will be evaluated, examined, gauged, compared. We will delay our activities and postpone our scientific results, to prepare the best possible case for our work. But, hopefully, we will end up with even better conditions to host the best researchers and do the best science. So, keep watching this space, interesting times are here...

José Afonso, Director of CAAUL

News from CAAUL

ENAA 2013

The national meeting of Astronomy and Astrophysics (ENAA) has been organized every year since 1991. It is the single place where the whole community of astronomers working in Portugal and those Portuguese working abroad have a chance to meet, share recent results and discuss common goals as a community. ENAA is promoted by the Portuguese astronomy society (SPA) and besides the scientific meeting it also includes the yearly SPA member's meeting as well as a session aimed at a non-expert audience.

The organization of ENAA alternates between various research centers. This year it was hosted by CAAUL and took place at Faculdade de Ciências da Universidade de Lisboa on July 18th and 19th. The public session was held at the Astronomical Observatory of Lisbon (OAL) and consisted of a guided tour of the observatory and a colloquium about the standard model of cosmology and the recent results of the Planck space mission. The event

was announced in the media, being highlighted in the “Agenda Cultural de Lisboa” and in the TV show “Sociedade Civil”.

Participation in the scientific meeting was quite high (around 70), including some interested undergraduate students. The majority of the participants came from various institutions in Lisbon and Porto, but there were also several people from other places such as Coimbra, Aveiro and Évora. There were around 40 oral communications and 10 posters, spread over 9 sessions covering a broad range of astrophysics, from the smallest to the largest scales of the universe. These were: planetary systems, stellar properties, stellar evolution, the Milky Way galaxy, extra-galactic astrophysics, cosmology, astroparticle physics. There was also a transversal session on instrumentation for astronomy and a session dedicated to outreach.

The Portuguese astronomy community is relatively small, the SPA

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This newsletter is available at

<http://www.caaul.oal.ul.pt/gazette>

Visit CAAUL at Facebook and Twitter, where you can keep informed about the latest news and events:

www.facebook.com/caaul.astro
www.twitter.com/caaul_astro

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:

14 October to 17 October 2013:

The Dark Side of the Universe – IX International Workshop, SISSA, Trieste, Italy

14 October to 18 October 2013:

Communicating Astronomy with the Public 2013 (CAP2013), Warsaw, Poland

22 October to 25 October 2013:

Euclid WL – SWG and OU – SHE Joint Meeting, Rome, Italy

4 November to 8 November 2013:

Weak Lensing Magnification: Simulations and Measurements, Barcelona, Spain

11 November to 15 November 2013:

The Emergence of Disk Galaxies, Western Cape, South Africa

19 November to 20 November 2013:

ALMA Community Days 2013: Preparing for Cycle 2, ESO Garching, Germany

Outreach:

Every last Saturday of the month:

Nights at the Observatory

This public outreach activity takes place at the Astronomical Observatory of Lisbon. In each session there will be a guided tour to the historical main building of the Observatory, a public talk, usually given by a CAAUL researcher, and guided observations of the night sky.

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members numbering around 100, and does not specialize in a few chosen topics but is traditionally dispersed among many topics. This tradition may have the downside of not reaching a meaningful size at international level on any field, with a few exceptions. On the other hand this makes ENAA an interesting meeting, the only chance to learn first-hand about research on all branches of astronomy at times where one mostly attends highly-focused workshops. In order to narrow the focus and find common ground, the meeting ended with a round table discussion. This consisted of a few contributions on national strategic topics. One current concern is the need to grow and join international large collaborations in order to be better placed to apply to European funding in the framework of the upcoming Horizon 2020 programme. The discussion was centred on the



ENAA poster session at the Faculty of Science, University of Lisbon

if-when-and-how of producing a roadmap for astronomy in Portugal.

Ismael Tereno

Extragalactic astronomy session ...

The extragalactic session showed a variety of interesting arguments which are investigated nowadays in Portugal. We started with the keynote talk by Jarle Brinchmann on the EUCLID mission legacy science; the telescope is planned to be launched in 2020, and Portugal's one of the members of the consortium since early 2012.

CAAUL participates actively in the Sky Survey Working Group, which has the central task of defining the optimal pointing sequence to be followed by the telescope during the 6year flight. Another important mission in which Portugal is involved in is Gaia, a space observatory to be launched in November 2013 that will create a precise three dimensional map of more than a thousand million stars throughout our Galaxy and extragalactic objects, of which at least 500 000 are quasars, mapping their motions, luminosity, temperature and composition. This huge stellar census will provide the data needed to tackle an enormous range of important problems related to the origin, structure and evolutionary history of our Galaxy. Portugal is involved in this project with the study of Active Galactic Nuclei (AGN), as Gaia will open up a huge volume of new parameter space in which to explore the physics of AGN and black hole evolution, and is also developing a method to analyze the images through the combination of Gaia simulated data and accurate radioastronomy that, once real data are available, will probe directly the geometry and physics of the targets as never done before. Other investigation lines presented at ENAA included the study of the interstellar medium of extremely metal poor III/ Blue Compact Dwarf galaxies using Integral Field Unit spectroscopy, optical and CO observations of type 2 quasars at intermediate redshift and the infrared universe as observed by the Herschel Virgo Cluster Survey (HeViCs).

Elvira Leonardo

Cosmology session ...

The session on cosmology was mostly devoted to theoretical aspects. In this sense it was not fully representative of current research in Portugal, where the field of observational cosmology has been growing. Indeed, there are Portuguese researchers involved in the recent results of the Planck mission (which was the subject of the public session talk) and in the scientific preparation of the Euclid mission, which had had a strong presence in last year's ENAA when the then recent membership of Portugal into this consortium had been presented.

The session's keynote talk was an overview of the various types of extensions of the theory of gravity that have been proposed to explain the late-time acceleration of the universe. It was a quite complete overview appealing also to non-cosmologists. The alternative explanation of this feature, namely dark energy, was also discussed in some of the talks. In particular a new model for dark energy, based on 3-forms, was presented, as well as a model with Lorentz symmetry-breaking. These (modified gravity theories and dark energy models) are central topics of current international research in cosmology and were also the subject of the recent international school "Modified Gravity Theories: Beyond Einstein's Legacy" co-organized by CAAUL very recently, in 16-18 September 2013. A by-product of dark energy models is the possibility of generating a time-variation in some fundamental constants of physics. Possible ways to test this effect were presented, along with forecasts for such measures with future Euclid and E-ELT data. The two remaining talks discussed well-confined and very diverse problems. One presented analytical derivations, in the framework of general relativity, for the collapse of matter in an expanding universe, while the other showed numerical simulations of topological defects in the early Universe.

Ismael Tereno

Recent Publications

- ◆ A. Liddle and M. Cortés. "Cosmic Microwave Background Anomalies in an Open Universe", 2013, Physical Review Letters, 111, 111302.
- ◆ De Looze, et al. (incl. C. Pappalardo and M. Grossi). "The Herschel Virgo Cluster Survey - XIV. Transition-type dwarf galaxies in the Virgo cluster", 2013, Monthly Notices of the Royal Astronomical Society, in press.
- ◆ T. Harko, F. Lobo, M. Mak, S. Sushkov. "Structure of neutron, quark, and exotic stars in Eddington-inspired Born-Infeld gravity", 2013, Physical Review D 88(4).
- ◆ T. Harko and F. Lobo. "Cosmological anisotropy from non-comoving dark matter and dark energy", 2013, Journal of Cosmology and Astroparticle Physics, 07, 036.
- ◆ S. Capozziello, T. Harko, F. Lobo, G. Olmo. "Hybrid modified gravity unifying local tests, galactic dynamics and late-time cosmic acceleration", 2013, International Journal of Modern Physics D 22, 1342006.
- ◆ C. Carvalho, I. Tereno, S. Basilakos. "CMB lensing reconstruction from the WMAP 7-year data", 2013, Physical Review D 88(6).
- ◆ H. Messias, B. Mobasher, J. Afonso. "Hot-dust (690 K) Luminosity Density and Its Evolution in the Last 7.5 Gyr", 2013, Astrophysical Journal, 776, 117.
- ◆ D. Farrah et al. (incl. J. Afonso) "Far-infrared Fine-structure Line Diagnostics of Ultraluminous Infrared Galaxies", 2013, Astrophysical Journal, 776, 38.
- ◆ H. Spoon et al. (incl. J. Afonso) "Diagnostics of AGN-Driven Molecular Outflows in ULIRGs from Herschel-PACS Observations of OH at 119 μm ", 2013, Astrophysical Journal, 775, 127.

AstroConundrum

Kepler and 'the Irreducible and obstinate facts'

I would like to invite you to read the provocative and beautiful book *The Sleepwalkers*, by Arthur Koestler¹. I shall not discuss Koestler's metaphor of scientists as sleepwalkers. Instead I will highlight Koestler's narrative on Kepler's personality, which puts us into contact with some decisive moments in Kepler's life, in a time much troubled by religious wars; a life that embodies the passage of the medieval to the modern world. Medieval and modern worldviews and ways of thinking are contained in Kepler's two books - *Mysterium Cosmographicum* (1596) and *Astronomia Nova* (1609). In the first, abstract generalization dominates a geometrical world without the balance of particular facts. In the second, written after intensive work on the orbit of Mars, developed alongside Tycho Brahe, a theory, built on years of labour and torment, was instantly thrown away because of the discord of a miserable eight minutes arc, as Koestler dramatizes it. To appreciate the difference in thinking in these two books, let us consider some fragments of Koestler's narrative - "while still a student in Tuebingen, he had heard from his teacher, Maeslin, about Copernicus, and agreed that the sun must be in the centre of the universe 'for physical or if you prefer, for metaphysical reasons'. He then began to wonder why there existed just six planets 'instead of twenty or a hundred' and why the distances and velocities of the planets were what they were". The answers to these questions emerge in a moment of great inspiration when Kepler draws a geometric figure on the blackboard, showing a triangle fitted by two circles. "As he looked at two circles, it suddenly struck him that their ratios were the same as those of the orbits of Saturn and Jupiter. The rest came in a flash. Saturn and Jupiter are the first (the two outermost) planets, and the 'triangle is the first figure in geometry. 'Immediately I tried to inscribe into the next interval between Jupiter and Mars a square, between Mars and Earth a pentagon, between Earth and Venus a hexagon...' It did not work - not yet, but he felt that he was quite close to the secret. 'And now I pressed forward again. Why look for two-dimensional forms to fit orbits in space? One has to look for three-

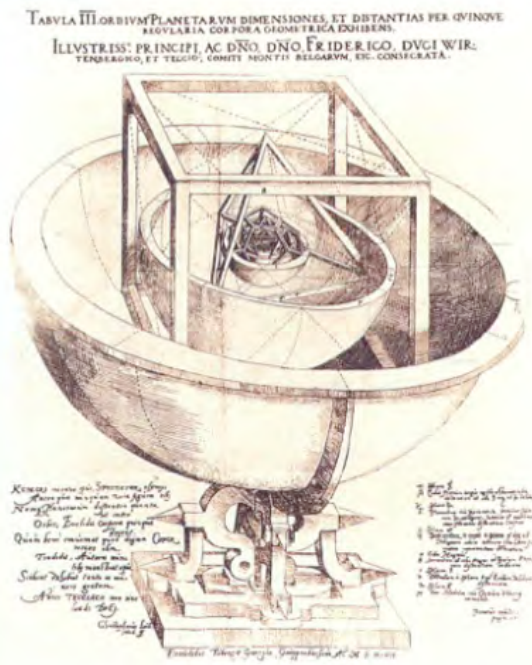
dimensional forms - and, behold dear reader, now you have my discovery in your hands!...'

The point is this. One can construct any number of regular polygons in a two-dimensional plane, but one can only construct a limited number of regular solids in three-dimensional space. These 'perfect solids', of which all faces are identical are [five] (...). Being perfectly symmetrical, each can be inscribed into a sphere, so that all of its vertices lie on the surface of the sphere. Similarly, each can be circumscribed around a sphere, so that the sphere touches every face in its centre. It is a curious fact, inherent in the nature of three-dimensional space, that (as Euclid proved) the number of regular solids is limited to five forms".

"So there existed only five perfect solids - and five intervals between the planets! It was impossible to believe that this should be by chance, and not by divine arrangement. It provided the complete answer to the question why there were just six planets 'and not twenty or hundred'. And it also answered the question why the distances between the orbits were as they were. All seemed to fit, more or less. Eureka! The mystery of the universe was solved by young Kepler". We can understand the delight that Kepler felt with all these abstract events. His imagination in looking for an intelligibility of an *a priori* perfect universe had no limits.

Astronomia Nova, is the beginning of modern thought. Here we find the first two laws. Kepler describes all his turns of thought - 'what matters to me is not merely to impart to the reader what I have to say, but above all to convey to him the reasons, subtleties, and lucky hazards which led me to my discoveries'. The discord of miserable eight minutes arc for the orbit of Mars¹ is the great protagonist of this book. The theory will capitulate

before this fact. For others this could be ignored 'but for us, who by divine kindness were given an accurate observer such as Tycho Brahe, for us it is fitting that we should acknowledge this divine gift and put it to use... Henceforth I shall lead the way towards that goal according to my own ideas. For, if I had believed that we could ignore these eight minutes, I



Model of the Orbits of the Planets' from *Mysterium Cosmographicum*, 1596

would have patched up my hypothesis accordingly. But since it was not permissible to ignore them, those eight minutes point the road to a complete reformation of astronomy: they have become the building material for a large part of this work'. We can follow the final capitulation of an adventurous mind before 'the irreducible and obstinate facts'¹. New adventurous ideas are emerging. As Whitehead writes- "it is this union of passionate interest in the detailed facts with equal devotion to abstract generalization which forms the novelty in our present society". What provokes these changes in Kepler's thought? One reason is all his work and experience, living and thinking in proximity of Tycho Brahe. Koestler associates it with the idea of causality that was growing in Kepler's mind - "it was his introduction of physical causality into the formal geometry of the skies which made it impossible for him to ignore the eight minutes arc (...)"

Koestler's narrative is a masterpiece for all, scientists, science educators, cultural historians. In it we can feel all the emotions, thought and suffering of a man who, by changing himself, has changed the vision of the universe.

¹ Koestler, A. (1989). *The Sleepwalkers - a history of man's changing vision of the universe*.

RedShift

Planetary Sciences: should they be considered in higher education syllabuses in Astrophysics?

In the solar system, planetary atmospheres, when they exist, are normally formed by turbulent fluids, and are driven by an energy input, the main source being the sun. Changes in solar activity may cause disruptions of different kinds in their physical and dynamical behaviour. For instance, regarding the earth's atmosphere, it seems that the 11-year sunspot cycle correlates with perturbations of the earth's climate; an example of this is the cooling of the earth during the Maunder's minimum (1645 – 1715), a 70-year period with weak solar activity, manifested by the absence of sunspots.

Also, changes in the cosmic ray flux in the earth's atmosphere can be responsible for changes in cloud formation, which, in turn, affect the water cycle and the energy budget of our planet, and ultimately the atmospheric circulation.

In the nineties of the last century, the concept of space weather was introduced to describe changes in environmental conditions taking place in near-earth space or in the space between the sun and the earth; space weather is fed by the energy of the solar wind propagating through the interplanetary space; part of space weather subjects are considered in books on meteorology, known as Aeronomy, the study of the high and very high altitude phenomena (e.g. ionosphere), in the earth's atmosphere.

It is therefore clear that topics such as fluid dynamics, turbulence, radiation, phase transitions, are all important, either in astrophysics or in planetary sciences.

When considering the interior of the planets, other topics such as plasma physics can be very relevant; such a topic is also highly crucial in stellar physics.

Other themes, like advanced topics in mathematics, numerical analysis, computing, statistics, remote sensing, are also common to astrophysics and planetary sciences.

For all these reasons, the introduction of a course in planetary sciences, or a course in meteorology, in the syllabuses of astrophysics in higher education, is, in my opinion, highly recommended; it will provide a sound physical foundation for a vast category of phenomena the students of astrophysics must face, when progressing into specific aspects of their own choice.

In Portuguese universities, courses in planetary sciences are not

London: Arkana.

² "The task before Kepler was to define the orbit of Mars (...). He chose out of Tycho's treasure four observed positions of Mars at the convenient dates". Kepler worked very hard "to determine, out of these four positions, the radius of the orbit, the direction of the axis, and the position of the three central points on it [position of the sun, orbital centre, and *punctum equans*] As a result of his seventy-odd trials, he arrived at values for the radius of the orbit and for the three central points, with a permissible error less than 2', the correct positions of Mars for all the ten oppositions recorded by Tycho". Kepler proclaimed his victory saying that the hypothesis based on his method 'not only satisfies the four positions on which it was based, but also correctly represents, within two minutes, all the other observations'. The next chapter of *Astronomia Nova* begins with these words: 'Who would have thought it possible? This hypothesis, which so closely agrees with the observed oppositions, is nevertheless false...' When he tried to adjust his model to much more observations, to "rare pieces from Tycho's treasure of observations", he arrived at a difference between the positions calculated from his theory and the positions of Mars observed by Tycho. A difference of eight arc minutes.

³ This is a Whitehead's expression. See Whitehead, A. (1997 - 1st edition 1926). *Science and the Modern World*. Free Press.

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A Supercell, where convection, vorticity, turbulence, radiation, phase transitions, all happen simultaneously, to produce an hazardous complex system

common in astrophysics syllabuses, not even as optional courses; the opposite situation is however relatively frequent in American or British universities.

The transition from the old structure in higher education to the Bolonha paradigm, should have been taken as an opportunity to create really new syllabuses, combining theory, technologies and innovative practices; unfortunately the basic old structure remains, shortened to 3 years and producing, with honorable exceptions, graduates that are not even accepted by industry or services, due to poor preparation for real professions.

Let us see if the situation can change in the near future.

João Corte-Real

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