École internationale d'astrophysique de l'Oukaïmden
Oukaimden International School of Astrophysics

FIRST ARAB WINTER SCHOOL FOR ASTROPHYSICS

FAWSA

Program and Abstracts

Edited by : Zouhair Benkhaldoun

28 Nov – 03 Dec, 2016, Marrakesh, Morocco

Cover illustration

Andromeda Galaxy
So far so close.
(source : https://en.wikipedia.org/wiki/Andromeda Galaxy)

In the year 964, Abd al-Rahman al-Sufi described the Andromeda Galaxy, in his Book of Fixed Stars as a « nebulous smear ». Star charts of that period labeled it as the Little Cloud.
The Andromeda Galaxy is magnificent and huge, with a similar structure to our own Galaxy. It is estimated to have over twice the two to four hundred billion stars of our own Milky Way galaxy. At more than two million light years away, it's the furthest object to be seen with the naked eye. In a Universe in which most galaxies appear to be moving away from us, Andromeda is unusual, for it is drawing closer at about 100 kilometers per second. It is expected to collide with our own Galaxy in about four and a half billion years.
The Andromeda Galaxy is bright enough to be seen with the naked eye, even with some light pollution. Andromeda is best seen during autumn nights in the Northern Hemisphere, when from mid-latitudes the galaxy reaches zenith and can be seen almost all night. From the Southern Hemisphere, it is a springtime object and does not reach a high altitude over the northern horizon, thus making it difficult to observe. Binoculars can reveal some larger structures and its two brightest satellite galaxies, M32 and M110. An amateur telescope can reveal Andromeda's disk, dark dust lanes, the large star cloud NGC 206, and even some of its brightest globular clusters.

Preamble

OISA (Okaimeden International School of Astrophysics) , is a seasonal doctoral school. It has been proposed by the High Energy Physics and Astrophysics Laboratory (LPHEA), and adopted by the Oukaimeden Observatory Council

OISA aims to provide additional training to young researchers, enrolled in Master or Doctorate, to deepen their knowledge or to introduce them to various fields of astronomy, astrophysics and theoretical physics.

The 2016 edition is jointly organized with the First Arab Winter School for Astrophysics. FAWSA is supported by the Office of Astronomy for Development (OAD) of the International Astronomical Union (IAU) through a grant to the Harvard-Smithsonian Center for Astrophysics in collaboration with Cadi Ayyad University. FAWSA will provide a platform for astrophysics knowledge sharing, triggering collaborations between fellow Arab astrophysicists, and building a strong professional Arab community in the field.

The scope of this winter school covers the following fields :

1. Solar System and Exoplanets
2. Solar Physics
3. Galactic Astronomy : Stars, Stellar Clusters, Nebulae, SNR and ISM
4. Extragalactic Astronomy : Galaxy Formation and Evolution, and Cosmology
5. Observational Astronomy : HRA, Adaptive Optics, Site Testing.
6. Meteoritics and Impact cratering
7. Technical Tools : Python, IDL, Iraf, and Remote Observatory

Scientific Program

- **Monday** 28 **Nov** 2016
  - 8h30 – 10h00 : Opening Ceremony and Keynote Speech
  - 10h15 – 11h15 : Introduction to Research in Astrophysics, Zouhair BENKHALDOUN
  - 11h15 – 12h45 : Theoretical Spectroscopy, Kelly CHANCE
  - 14h15 – 15h45 : Extragalactic Astronomy , Ismael MOUMEN
  - 16h00 – 17h00 : IRAF and Python, Ahmed DAASSOU, Mohamed KAAB and Roger HAJAR
  - 17h00 – 18h00 : IDL, Ismael MOUMEN and Malki KHALIFA

- 18h30 – 20h30 : Public Conference : Astronomy within Islamic civilisation, Mohamed Zine El Abidine AL-HUSSEINI

– **Tuesday** 29 **Nov** 2016
  - 8h30 – 10h00 : Introduction to Cosmology, Pedro G. FEREIRA
  - 10h15 – 11h15 : Introduction to Galactic Astronomy , Randa ASS'AD
  - 11h15 – 12h45 : Multiple Stellar Population in Galactic star clusters , Randa ASS'AD
  - 14h15 – 15h45 : Theoretical Spectroscopy, Kelly CHANCE
  - 16h00 – 17h00 : Image Processing, Photometry, and Astrometry, Ahmed DAASSOU and Zouhair BENKHALDOUN
  - 17h00 – 18h00 : CCD Imaging Spectroscopy , Abdelmajid BENHIDA and Fouad SEFYANI
  - 18h30 – 20h30 : Public Conference : Light Pollution and Dark Sky Reserve, Martin AUBE

– **Wednesday** 30 **Nov** 2016
  This session will take place at Faculte des Sciences et Technique (FST Amph III)
  - 9h00 – 10h00 : Atmospheric Optics, Aziz ZIAD
  - 10h15 – 11h15 : Adaptive Optics, Jean Marc CONAN
  - 11h15 – 12h45 : Exoplanets, Andy SZENTGYORGYI

– **Thursday** 1 **Dec** 2016
  - 8h30 – 10h00 : Incursions in High Energy Astrophysics, Jamal MIMOUNI
  - 10h15 – 11h15 : Space Physics , Suleiman BARAKA
  - 11h15 – 12h45 : Space Physics, Suleiman BARAKA
  - 14h15 – 15h45 : Earth and Planetary Atmospheres , Kelly CHANCE and Raid SULEIMAN
  - 16h00 – 17h00 : Exoplanets Roger, FERLET
  - 17h00 – 18h00 : Meteoritics and Impact cratering, Hasnaa CHENNAOUI
  - 18h30 – 20h30 : Public Conference : KACCOLR Project for Crescent Observation, Yaseen AL MELEKEAY

– **Friday** 2 **Dec** 2016
  - 8h30 – 10h00 : Gamma Universe, Nidhal GUESSOUM
  - 10h15 – 11h15 : The Standard Model and Beyond at LHC, Mohamed CHABAB
  - 11h15 – 12h45 : Solar Physics, Raid SULEIMAN
  - 14h15 – 15h45 : Solar Physics , Nicole VILMER
  - 16h00 – 17h00 : IRAF and Python, Ahmed DAASSOU, Mohamed KAAB and Roger HAJAR
  - 17h00 – 18h00 : Remote Observatories, Thibault DE FRANCE and Abdelmajid BENHIDA

- 18h30 – 20h30 : Science at the Universities of the Arabic World, Nidhal GUESSOUM

– **Saturday** 3 **Dec** 2016
  - 8h30 – 18h00 : Oukaimeden Observatory Visit
  - 18h30 – 20h30 : Final Address

Subject covered and Speakers :

– **General Lectures :**
  – Introduction to Reasearch in Astrophysics (Zouhair Benkhaldoun)
  – Introduction to Cosmology (Pedro G. Fereira)
  – The Standard Model and Beyond at LHC (Mohamed Chabab)
  – Incursions in High Energy Astrophysics (Jamal Mimouni)
  – Theoretical Spectroscopy (Kelly Chance)
  – Galactic Astronomy (Randa Ass'ad)
  – Extragalactic Astronomy (Ismael Moumen)
  – Solar Physics (Nicole Vilmer and Raid Suleiman)
  – Space Physics (Suleiman Baraka)
  – Earth and Planetary Atmospheres (Kelly Chance and Raid Suleiman)
  – Exoplanets (Andy Szentgyorgyi and Roger Ferlet)
  – Meteoritics and Impact cratering (Hasnaa Chennaoui)
  – Atmospheric Optics (Aziz Ziad)
  – Adaptive Optics (Jean Marc Conan)
  – Gamma Universe (Nidhal Guessoum)

– **Tools :**
  – Image Processing (Zouhair Benkhaldoun and Ahmed Daassou)
  – CCD Imaging, Photometry, and Astrometry (Ahmed Daassou)
  – CCD imaging Spectroscopy of the variable star RR lyrae (Abdelmajid Benhida and Fouad Sefyani)
  – IRAF, IDL, Python (Ismael Moumen, Ahmed Daassou and Mohamed Kaab)
  – Writing a Scientific Paper (Raid Suleiman)
  – Virtual Observatories (Abdelmajid Benhida and Zouhair Benkhaldoun))

– **Public Conferences :**
  – Astronomy within Islamic Civilisation (Mohamed Zine Elabidibe Houssaini)
  – KACCOLR Project for Crescent Observation (Yaseen Al Malekeay)
  – Light Pollution and Dark Sky Reserve (Martin Aube)
  – Science at the Universities of the Arabic World (Nidhal Guessoum)

Local Organizing Committee

- Zouhair BENKHALDOUN : Oukaimeden Observatory, Cadi Ayyad University, Marrakech
- Mohamed CHABAB : LPHEA UCA, Marrakech
- Aziza BOUNHIR : FST, UCA, Marrakech
- Abdelmjid BENHIDA : FST UCA, Marrakech
- Fouad SEFYANI : FST UCA, Marrakech
- Abdelhadi JABIRI : FSSM, UCA, Marrakech
- Mohamed LAZREK : FSSM, UCA, Marrakech
- Ahmed DAASSOU : Observatoire Universitaire Cadi Ayyad, UCA, Marrakech
- Thami EL HALKOUJ : LPHEA/CRMFE, Marrakech
- Tarik KHALLA : FSSM, UCA, Marrakech
- Mohamed Younes JAMJARI : 3AM Marrakech

Zouhair Benkhaldoun
Marrakech, November 2016

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Lecture 1

Introduction to Research in Astrophysics

By **Zouhair BENKHALDOUN**

Astronomy has, historically, been a fascination for humans. This discipline, first born from philosophy and mathematics, has become the most global of all sciences. Planetology, Astrobiology, Archeoastronomy are all directly or indirectly related to Astronomy and Astrophysics. They involve physics and chemistry, geology, biology, in addition to mathematics and philosophy.

The enigmas about the birth and construction of our universe abound and are still not all resolved. There is a consensus in the community regarding the age and expansion of the universe. But this vision implies that the matter we can observe only constitutes 5% of the universe, while the remaining 95% is classified in the black energy and dark matter cells. There are still many mysterious concepts, demanding more developments, especially in the field of high energy physics or even regarding the models currently governing physics : a new physics is, indeed expected.

There has been many recent discoveries about planets orbiting around other stars than the sun. But we still don't know of the nature and the details of stars like the sun and its planetary system. The recent spectacular development in this part of astronomy, exoplanetology, is reviving a long-standing debate. When does life begin ? And are we alone in the universe ? So many questions that never cease to interest a large public and to question astronomers and philosophers.

In this lecture i will give an overview of the main fields we need to explore to do a scientific research in modern astrophysics. I will give an overview on the quantities, concepts, techniques, and conventions essential to do research in astronomy and astrophysics. The talk includes : A historical and practical preview of astronomy ; a census of astronomical objects and phenomena ; astronomical unit systems, classification schemes, observables, and orders of magnitude ; an astrophysical dimensional analysis ; basics of telescopes, instrumentation, and calibration.

Furthermore, I wil emphasize the importance of the use of databases and online resources ; experimental design ; introducing statistics and modeling ; and will conclude with an introduction to the publication process.

Lecture 2

Introduction to Cosmology

By **Pedro G. FEREIRA**

I will discuss the recent developments in Cosmology, focusing on our understanding of the large scale structure of the Universe.

Lecture 3

The Standard Model and Beyond at LHC

By **Mohamed CHABAB**

In this short course, I introduce the structure the Standard Model (SM), as a framework unifying the electroweak and strong interactions. I begin with a general discussion of particle physics, then proceed with theoretical construction of the SM as a non abelian gauge theory. This is followed by a treatment of spontaneous symmetry breaking with the Higgs mechanism and a description of how the masses of particles are generated via the Higgs boson field. Then, I discuss some phenomenological aspects of the Higgs Physics in relation with the LHC experiments. This course will be concluded by a brief outlook of physics beyond the Standard Model.

Lecture **4**

A Brief Introduction to High-Energy Astrophysics

By **Nidhal GUESSOUM**

In this lecture, I will review the main aspects that distinguish the field of high-energy astrophysics and its phenomena, including the observational instruments. I will also give a few examples of recent hot topics of research in the field, such as gamma-ray bursts, black hole accretion disks, and the activity at the center of the Milky Way galaxy. Starting with the range of energies and temperatures that characterize high-energy phenomena, I will introduce the physical processes (both thermal and non-thermal) at play there : nuclear reactions, pair (creation and annihilation) processes, Bremsstrahlung, Comptonization and Inverse-Comptonization, accretion, stellar collapse (supernovae and hypernovae), acceleration mechanisms (shocks, etc.), and others. I will also briefly present the main methods of detection of high-energy photons and mention the current instruments that are operating in space as well as some of the planned (future) ones. Finally, I will give quick snapshots of what we know today about gamma-ray bursts (the observational evidence and the main models) as well as other hot topics in the field : accretion disks around black holes, the center of our galaxy, etc.

Lecture 5

Incursions in High Energy Astrophysics

By **Jamal MIMOUNI**

High Energy astrophysics is the study of the highly energetic electromagnetic radiation from celestial objects as well as of cosmic rays (CR), neutrinos and even gravitational waves (GW). Each messenger probes specific aspect of the cosmos and helps bring a more complete picture of its content and properties. HE astrophysics is thus closely related to particle physics, and the relatively recent blossoming of the field is a tribute to the usefulness of probing the Universe in a multi-messenger fashion while the high energy aspect is synonymous of studying violent most energetic processes which unravel new hitherto unknown aspects of fundamental importance. To push further on the proximity of the field to particle physics, we may compare the acceleration mechanisms in sites like SNe , SNe remnants, quasars, accretion disks and the like, to the ones in colliders and synchrotrons machines, except that in the first case we are dealing with accelerator sites of cosmic size with un-collimated beams and highly complex environment compared to the relatively clean ones of accelerator's detectors. We shall review HE astrophysics particle by particle including the recently christened GW-astrophysics, but we will focus mainly on CR-astrophysics and ν-astrophysics.

Lecture **6**

Spectroscopy and Radiative Transfer of Planetary Atmospheres

By **Kelly CHANCE**

These two lectures introduce quantitative spectroscopy and radiative transfer in the atmospheres of planets from microwave through ultraviolet wavelengths. The physics of the interaction of radiation and matter in planetary atmospheres includes knowledge of how stellar or thermal radiation propagates through atmospheres, how that propagation affects radiative forcing of climate, how atmospheric pollutants and greenhouse gases produce unique spectroscopic signatures, how the properties of atmospheres may be quantitatively measured, and how those measurements relate to physical properties.

Examples of applications include systematic observation of the atmospheric constituents that affect weather, climate, biogeochemical cycles, and air quality on Earth, as well as the physics and evolution of other planetary atmospheres in our solar system and on exoplanets. Theoretical scientists need an understanding of the details, strengths and weaknesses of the spectroscopic measurement sources. Measurers require an understanding of the information content of the measured spectra that are needed for the design of retrieval algorithms and for developing new instrumentation

Lecture 7

Multiple Stellar Population in Galactic star clusters

By **Randa ASS'AD**

Galactic Astronomy is the branch of astronomy that studies our Milky Way galaxy.Under the broad topic of Galactic Astronomy I will focus on the stellar clusters as the building blocks of the Galaxy because they can provide us with information about the formation history. Stellar clusters are laboratories for testing different stellar evolution theories, so I will start by reviewing the stellar evolution and apply it in stellar clusters. Special attention will be given to different methods of obtaining the age of both resolved and unresolved star clusters using simple stellar population models. In order to relate this to current research topics I will present the idea of multiple stellar populations and provide current evidence from the literature on multiple stellar population in galactic clusters.

Outline of the presentation :

- Day 1 ($1.5hr$)
  - introduction and review of stellar evolution
  - General information about our Galaxy
  - Introduction to star clusters and ways of determining their age using single stellar population models
- Day 2 ($1.5hr$)
  - The idea of Multiple Population (evidence from the literature and open questions).
  - Discussion

Lecture **8**

A Short Introduction to the World of Galaxies

By **Ismael MOUMEN and Aycha TAMMOUR**

Since the famous Great Debate (the Shapley-Curtis Debate) in 1920, the field of Extragalactic Astronomy has emerged as one of the main areas in astronomy that shapes our understanding of the universe. In this talk, we present an overview of the major topics in Extragalactic Astronomy covering areas such as galaxy classification and evolution, distance determination, supermassive black holes and active galactic nuclei (AGN). We highlight some of the open questions in the field and current and future projects working on answering them.

Lecture **9**

Space Weather Impacts of Flares, Coronal Mass Ejections and Solar Energetic Particles

By **Nicole VILMER**

Our sun is a magnetic and active star. This has been known since the 17th century from the observations of sunspots at the solar surface. In the 19th century the solar sunspot cycle was discovered as well as the first impacts of disturbances of solar origin on the technology. This is in particular the case of the famous Carrington event on the 1st September 1859 at the Sun which led to the disruption of telegraphs for many hours after the event. Nowadays, our hi-tech world has become more and more vulnerable to disturbances from the Sun, in particular to the eruptive events associated with the release of magnetic energy in the solar atmosphere. Different phenomena related to solar activity can disturb our space environment : the amount of solar flux, in particular the ionizing solar flux impinging on the Earth, the level of geomagnetic activity induced in particular by gigantic coronal mass ejections which may reach the earth after a few days of propagation or the production of energetic particles associated with flares or coronal mass ejections that can reach the Earth's orbit after a few tens of minutes to hours.

Attempting to couple solar « events » (flares, coronal mass ejections, particles) to perturbations in the earth's atmosphere is a challenging issue that requires the coordination of many data obtained through many different techniques from many instruments together with the development of models to track e.g. the propagation of mass ejections, shocks or particles in the interplanetary medium. I will introduce first the different phenomena related to solar activity : solar flares, solar energetic particles and coronal mass ejections and their counterparts in the interplanetary medium. For the propagation of coronal mass ejections from the solar atmosphere to the interplanetary medium, I will show on a few examples how the recent observations from the STEREO mission allow to better connect coronal mass ejections at the Sun with in situ measurements. I will also present how models allow to follow the solar wind perturbations from the sun to the earth and beyond. Understanding the origin of solar energetic particle (SEP) events also requires a combination of observations and modeling. The most energetic SEP events produce a detectable ground level enhancement (GLE) in the cosmic-ray flux and are detected by the network of neutron monitors. 70 GLEs have been observed so far with proton enhancements extending up to 10 GeV. I will introduce the observations of the SEP events and discuss the models and tools developed to study the propagation of the energetic particles in the interplanetary medium. The question of where these particles are accelerated remains a debated issue. Apart from being accelerated at the Sun, particles can also be accelerated by the CME shocks in the interplanetary medium. I will finally discuss the input of radio observations to these issues.

Lecture **10**

Solar Physics

By **Raid SULEIMAN**

Solar physics lecture provides a balanced and quantitative description of the sun and of techniques used in solar research. An overview of the sun, solar atmosphere and the standard model of the sun and detailed description of solar magnetohydrodynamics and the role it plays in the solar atmosphere and solar eruptions are explored. Details of the source regions and mechanisms of the solar wind and interaction with the heliosphere are presented. Observations from Solar Heliospheric Observatory (SOHO) and the Solar Dynamic Observatory are shown to highlight the theoretical concepts. Various concepts and observational techniques are presented.

Lecture 11

Space Physics

By **Suleiman BARAKA**

The magnetosphere is the highly asymmetrical vast region of space connected to the Earth, in which the planet magnetic field and related large scales currents control the behavior of charged particles. The presence of plasmas of different origins in the immediate vicinity of Earth triggers the coupling between electromagnetic fields and particles, producing currents and induced fields that may substantially modify the whole environment of the planet. The source of the energetic charged particles inside the Earth magnetosphere is either from the solar wind or from flux tubes coupled from high-latitudes ionosphere. Tools for studying such complex systems are introduced. Namely, we will present theoretical physics background of space plasma physics. Then, we will present 4 data systems related to space physics, such as AMDA, SPEDAS, and we will preset a sample of our work in space physics modelling by Particle-In-Cell (PIC EM Relativistic code) as a case study.

Then we will show how results from numerical simulations will be compared with in situ observations provided by magnetospheric space missions operated by the European (ESA) and American (NASA) space agencies.

Lecture **12**

Detection and characterization of exoplanets

By **Roger FERLET**

Are we alone in the Universe ? We are living the exciting epoch in which this simple, millennial question can be tackled with the scientific method. Presently, more than 3540 planets orbiting other stars than our Sun have been detected through different methods. I will describe these methods, focusing on photometric ones. Furthermore, it is becoming possible to detect and characterize the atmosphere of some extrasolar planets through transmission spectroscopy. One of the challenges is now to discover an Earth-like exoplanet in the habitable zone of its parent star.

Lecture 13

Exoplanets from a Spectroscopic Perspective

By **Andy SZENTGYORGYI**

The course begins with a brief summary of the constituents of our Solar System from an exoplanet science perspective. Our solar system is then compared with exo-solar systems in a survey of known exoplanet systems that define the parameter space in which exoplanets have been detected and in which we hope to discover in the coming decade. A detailed description of the spectroscopic observational techniques and instrumentation that are available today or the immediate future for the detection and characterization of exoplanets is presented. The problem of detecting and characterizing exoEarths, especially the problem of differentiating exoplanet reflex signal from stellar activity is reviewed. The course closes with a discussion of how we might detect evidence of exobiotic activity, especially in exoplanet atmospheric transmission spectra.

Lecture **14**

Meteorites and Impact craters in Arabic countries : An overview

By **Hasnaa CHENNAOUI AOUDJEHANE**

During the last fifty years, meteorites have been a fantastic way to increase our knowledge about the origin of the solar system, the formation of planets including the Earth, the large impact-related extinctions during the geological times ... Their study allowed scientists to have a direct access to rocks from planets not yet directly explored, and also to rocks that represent the precursor of the actual planets, that have been fixed in the initial state of their formation as asteroids. Meteorites : Arabic countries are very rich in meteorite finds. Collection of meteorites is essentially done in hot and cold deserts. Most of the Arabic countries contain large desert areas, explaining why they are a very good place for searching meteorites. Those meteorites are quasi totally exported out of their countries of find, by dealers, collectors or foreign scientists. All classes of meteorites are found in the hot deserts ; a lot of them are rare and potentially very important for the scientific research in particular due to their origin : most of martian meteorites, lunar meteorite, angrites and other rare types are from the hot deserts. All meteorite falls since 2004 : « Benguerir », « Tamdakht », « Tirhert », « Tinajdad », « Sidi Ali Ou Azza », « Izarzar ») has been classified and submitted to the Nomenclature Committee of the Meteoritical Society by our team including the exceptional fifth Martian meteorite fall in Morocco « Tissint ». Many valuable papers have been published on these falls allowing Moroccan researchers to comfort their position on this topic. A similar effort was done with meteorite finds in Morocco such as « Al Haggounia », « Anoual », « Bou Azarif », « Agoudal », ... Most other finds from the countries surrounding Sahara (Morocco, Algeria, Tunisia, Mauritania Mali, Tchad, Niger ...) are called by a serial name (North West Africa) followed by a number : NWA xxx . The lack of locality name means that we don't know the exact origin of the sample, thus we loose important scientific and patrimony information. In Lybia and Oman, there are large meteorites strewnfields with known geographic coordinates and a serial name plus a number like Dar El Ghani (DAG xxx), Hamada Al Hamra (HAH xxx), Shisr xxx, ... In Egypte, there is one of the most famous martian meteorites falls, Nakhla, as well as the most ancient meteoritic iron, found in the King Tut treasure. In Saudi Arabia, there is a recent impact meteorite crater : the Wabar crater, while the black stone in the Kaba Al Mounaouara is said to be possibly a meteorite. Despite of this richness, Arabic countries does not have laboratories devoted to research on meteorites, they doesn't have museums for the preservation of this patrimony that is lost quickly. Indeed, most meteorites exported from Sahara are sold to private collectors with no benefits to Science and to the countries. It's important to have a smart regulation as well as research centres and museums have to be created in Arabic countries. Impact craters : In Arabic countries, the number of impact craters is 11, this number is very low comparing to those known in USA or Europe. In Morocco, the first impact structure has been discovered by chance

during a systematic search of an iron meteorite « Agoudal ». This structure is interesting : even it has been found in the Agoudal meteorite area, there is no relationship between both events. Efforts are made to develop planetary sciences in Morocco and Arabic countries and to connect Meteoritics researchers and Astrophysicists by organising scientific meeting by the Hassan II University of Casablanca (Desert meteorite workshop August 2016, Arab Impact Cratering and Astrogeology Conference AICACII November 2011, 77th Meteoritical Society Meeting). This effort includes also communication on newspapers, radio and TV media to inform the large public about these sciences as well as the introduction of courses on the university curricula

Lecture 15

Atmospheric Optics

By **Aziz ZIAD**

Light observed from astronomical objects undergoes perturbations while passing through the atmosphere resulting in image blurring and twinkling (seeing and scintillation). A major limiting factor for ground based astronomy is the atmospheric turbulence due to fluctuations of the refractive index. A solution to overcome the effect of atmospheric turbulence is the use of an adaptive optics system (AO). The specifications of an AO system requires necessarily detailed knowledge of the characteristics of the atmospheric conditions of the site. Indeed, the overall design and study of future high-resolution instruments require a better understanding of atmospheric turbulence. AO systems have been constructed for most major telescopes and this has resulted in an improved system performance along with access to new scientific research.

The Laboratoire H. Fizeau at the University of Nice-Sophia Antipolis (UNS) is a leader in the area of atmospheric optics, and the team has been recognized both nationally and internationally for their work in site-testing. The laboratory has extensive experience in atmospheric physics, turbulent flow, and geophysical effects on optical turbulence. Our range of expertise includes developing new instrumentation through implementing the software required to model the atmosphere. We have developed and deployed several devices at a number of sites for large telescopes including GranTeCan (Canary Islands), VLT (Chile), and Gemini (Chile) ; and they are contributing to the site-testing for the E-ELT, the Thirty Meter Telescope (TMT), and Dome C in Antartica.

One of the objectives of my talk during the FAWSA event is the presentation of the Atmospheric Optics and Site-Testing thematic. This thematic deals with the problem of propagation of light waves in a turbulent medium such as the atmosphere. This is to study the influence of turbulence disturbances on the images for the characterization of wavefronts. It will also be question of statistical analysis of the wavefronts for estimating spatial, temporal and angular coherence parameters of the wavefronts. The impact of these parameters on high resolution techniques such as AO and interferometry will also be addressed. Application of these techniques is not limited to the light propagation through the atmosphere. They are also used to address issues related to the propagation of light in turbulent environments (horizontal propagation above the sea surface, endoatmospheric observations, fast imaging in industry through a turbulent medium, satellite tracking...).

Lecture **16**

Adaptive Optics for high angular resolution astronomical instruments

By **Jean-Marc CONAN**

Adaptive optics provides a real time correction of atmospheric turbulence and allows obtaining nearly diffraction limited astronomical observations on large ground based telescopes. We will present the basics of adaptive optics, and introduce recent strategies aiming at either very high contrast (exoplanet direct detection, circumstellar disks imaging) or wide field of view (galactic and extra-galactic spectro-imaging). Illustrations of adaptive optics systems for the Very Large Telescopes (10m class) will be given, and the challenges of the current developments for future Extremely Large Telescopes (30 to 40 m class) will be discussed.

Lecture **17**

CCD imaging Spectroscopy of the variable star RR lyrae

By **Abdelmajid BENHIDA and Fouad SEFYANI**

CCD imaging has become one of the most influential technologies for astronomers over the past decade. That one single technological advancement has allowed advanced astrophysics via spectroscopy. For years, astronomers have been using home built spectroscopes and spectrographs to see and record the spectra of astronomical objects. Traditionally this has been done visually and with film. Now, since CCD's have become much more affordable, astronomers can capture spectra quicker and in a more usable format : digital. In this workshop, we will show you the method of acquisition and reduction of spectroscopic data, which we obtained for the study of the variable star RR lyrae . Indeed, In this work we used an optical fiber-fed echelle spectrograph eShel of the Shelyak Instruments company. The eShel system includes a $F/6$ Fiber Injection and Guiding Unit, a $50\mu m$ optical fiber, a $ThAr$ Calibration Unit, and an echelle spectrograph ($125mm$ $F/5$ collimator, $R2$ echelle grating, cross-dispersing prism, $85mm$ $F/1.8$ objective). The spectrograph was installed on a $C14$ Celestron telescope at the Oukaimeden observatory situated at an altitude of $2700m$ in the High Atlas mountains, $78km$ south of Marrakech. The pixel size was $6.8\mu m$, and the spectral dispersion was $16\,\text{Å}/mm$ or $0.1\,\text{Å}/px$. We obtained consecutive spectra over a large part of the visible domain (from 4100 to 7200 Å), between orders 32 and 52 and with a resolution power of about 12000. With an exposure time of $300s$, the signal-to-noise ratio (S/N) is about 30. The data were reduced with the free and open source astronomy software AudeLA (http ://audela.org/dokuwiki/doku.php/en/release/start). This package performs classical operations, such as bias subtraction, flat-fielding, masking of bad pixels, wavelength calibration, and spectrum extraction, including extraction of the spectroscopic information.

Lecture 18

Images processing by IRAF

By **Ahmed DAASSOU**

The goal of this practical work is to become familiar with IRAF through its various commands and packages in order to make a correct processing of astronomical images. To achieve this goal, we will use a raw images acquired by our team. In first time, we will pre-process the raw images by eliminating the various noise sources (Dark, Bias, Flat), using for this a script that we developed in our laboratory. Since these images are not aligned, the next step is to align the pre-processed images with respect to a reference image (often the first image). A script has been developed to perform this step. As application, and in order to extract scientific information from astronomical images, we will apply the aperture photometry technique on pretreated and aligned images (script developed in python), especially on target star and selected references stars, to finally get a light curve of the studied target.

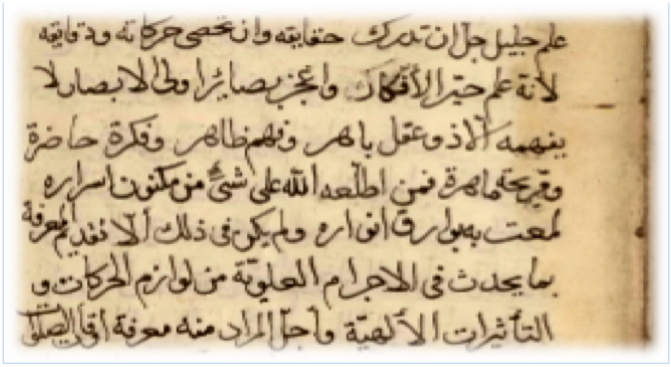
Lecture **19**

Astronomy within Islamic civilisation

By **Mohamed Zine El Abidine HOUSSAINI**

علم الفلك ضمن منظومة الحضارة الإسلامية

مما لا شك فيه أن علم الفلك يشكل أهمية كبرى بالنسبة لمنظومة الحضارة العربية الإسلامية، وضمنها المغربية، لكونه لا يمثل علما فحسب، وإنما يعد عنصرا فعالا بالنسبة للعبادات، لما له من دور في دعم علم التوقيت، الذي بدونه لا يمكن قبول العبادات على وجهها الأكمل، باعتبار أن الصلاة مثلا " كانت على المومنين كتابا موقوتا".و "علم الفلك هو الدراسة العلمية للأجرام السماوية والظواهر التي تحدث خارج نطاق الغلاف الجوي ، مثل إشعاع الخلفية الميكروني الكوني. و يدرس تطور الأجرام السماوية، بالإضافة إلى تَكَوُن وتطور الكون.". ويعرفه الحسن ابن الهيثم بأنه:" علم جليل جل أن تُدرَك حقائقه، وأن تُحصى حركاته ودقائقه، لأنه علم حير الأفكار وأعجز بصائر أولي الأبصار، لا يفهمه إلا ذو عقل باهر، وفهم ظاهر، وفكرة حاضرة، وقريحة ماهرة.."



الحسن ابن الهيثم، رسالة في علم الفلك .

ويرتبط علم الفلك بعدة علوم، من بينها علم الهيأة، وعلم الأزياج، وعلم التوقيت... ومن أهم فروع علم الفلك الحديث، علم قياس مواقع النّجوم في السّماء بدقّة كافية ورصد تحرّكاتها. وعلم رصد حركة الكواكب والأقمار في مجموعتنا الشّمسية والتنبّؤ بهذه الحركة في ظلّ قانون الجاذبية. وعلم دراسة طبيعة الكواكب وعلم فيزياء النّجوم ودراسة محيط ما بينها.وهو ما يعرف بالفيزياء الفلكية. مع علم دراسة الكون بمجمله في إطار فيزياء الكون.

على أن دراسة علم الفلك ضمن الحضارة الإسلامية وضمنها المغربية سيتم تناوله من خلال ثلاثة محاور رئيسية :

+ علماء ومخطوطات في علم الفلك: لا يمكن الحديث عن علم الفلك دون التعريف بالعلماء المسلمين في هذا الميدان، ومن بينهم أبو علي الحسن ابن الهيثم ، مؤلف العديد من الكتب في هدا الميدان، والبيروني، والبتاني، والصوفي...إضافة إلى العلماء المغاربة، كابن البناء المراكشي، مؤلف كتاب: " الكلام الكلي الضابط لأحكام النجوم."، وأبو القاسم أحمد ابن عبد الله الصفار ، مؤلف "رسالة في الأسطرلاب "، وعبد السلام العلمي... والملاحظ أن العديد من المكتبات الوطنية والدولية تضم في رفوفها العديد من المخطوطات التي ما تزال بحاجة للبحث والتحليل لاكتشاف محتوياتها ذات الطابع العلمي.

+ أدوات وآلات في علم الفلك :إن الحديث عن علم الفلك يتطلب ضرورة التعريف بالآلات والأدوات التي كان يتم الاعتماد عليها واستعمالها للتعرف على الظواهر الفلكية وضبط مكوناتها بشكل علمي دقيق، ومن بين أمثلتها الأسطرلاب الذي يعد قمة التفاعل بين العلم والصنعة، والكرة السماوية، والربع المجيب، وآلة ربع الشعاع والظل...وغيرها.

+ التفسير العلمي للظواهر ووظيفية علم الفلك :إن الحرص على اعتماد الجانب العلمي في وصف وتفسير الظواهر الطبيعية يعود أساسا إلى حض الإسلام على التدبر في ملكوت السماوات والأرض، واستعمال ا لعقل في تفسير هذه الظواهر بعيدا عن الأسطورة والخرافة. حيث أن الكون يتضمن آيات لا يدرك كنهها إلا أولو الألباب. ومن ثمة كان اعتبار الفلك علما له ضوابطه وأسسه ومكوناته يدرس بالجامعات، وفي مقدمتها جامعة القرويين وجامعة ابن يوسف، اللتان كان التعليم بهما وظيفيا، وكان المتخرجون المختصون في هذا العلم إلى جانب علوم أخرى تسند إليهم مهمة التوقيت، وضبط المسافات، وتحديد مسارات القوافل والمسافرين والجيش. وهو ما يدل على أهمية ووظيفية علم الفلك.

إن تعريف الأجيال الحالية بالتراث العلمي العربي الإسلامي في العديد من المجالات ومن بينها الفلك، يعد بمثابة شحنة علمية تساهم في إغناء الموروث العلمي وتطويره، للتحفيز على الابتكار والإنتاج، وتجنب النمطية والاستهلاك، وتلك قيم ينبغي بعثها من أجل التطوير والتجديد، والاعتزاز بما بذله الأجداد في العديد من الميادين، واتخاذ كل ذلك قدوة من أجل التقدم والتطور.

Lecture **20**

La nuit : une richesse à protéger

By **Martin AUBÉ**

Nous savons maintenant que la présence de lumière artificielle nocturne dans l'environnement a d'importantes conséquences sur le ciel étoilé, sur la faune, sur la flore ainsi que sur la santé humaine. Parallèlement, presque partout sur notre planète, la nuit est en voie de disparition en raison de l'accroissement généralisé de la quantité de lumière artificielle émise dans l'environnement nocturne. Au cours des dernières décennies, le taux d'augmentation de la quantité de lumière artificielle nocturne s'est opéré à un rythme moyen de 6% par année. A ce rythme, le niveau de pollution lumineuse double tous les 12 ans. Mais, au cours des dernières années ce taux de croissance semble vouloir s'accélérer pour atteindre près de 15% par an, à certains endroits du globe. Cette accélération est concomitante avec l'arrivée massive des systèmes d'éclairage public à base de diodes électroluminescentes (LED). Les LED offriraient de nombreuses possibilités : elles sont plus durables, facilement contrôlables et permettent généralement une conception photométrique plus efficace qui, à terme, peut entraÃ®ner des économies d'énergie. Par contre cette technologie peut contenir beaucoup de lumière bleue, dont les répercussions néfastes sur la voilement du ciel étoilé et surtout sur la santé de la faune et des humains sont très préoccupantes. De plus, son plus faible coût d'opération favorise leur installation en plus grand nombre.

Après avoir décrits quelques effets indésirables de la lumière nocturne, nous discuterons des mécanismes gouvernant la propagation de la lumière nocturne dans l'environnement. Nous expliquerons pourquoi les outils modernes de la recherche, dans le domaine de l'étude de la pollution lumineuse, peuvent nous aider à réduire de façon efficace les effets indésirables de la lumière artificielle nocturne sur le ciel et sur le vivant. Nous montrerons comment utiliser ces outils pour protéger des territoires contre la prolifération de la pollution lumineuse : les réserves de ciel étoilé. Des territoires ou la nuit devient une valeur culturelle, scientifique, et économique. Le cas de la première réserve internationale étoilé, située au Mont-Mégantic dans la province de Québec au Canada, sera cité en exemple. Nous évoquerons la possibilité d'instaurer une telle réserve autour d'Oukaimeden dans la province d'Al Haouz au Maroc.

Lecture 21

KACCOLR Project for Crescent Observation

By **Yaseen AL MALEKEAY**

عنوان البحث :الجوانب العلمية لمركز خادم الحرمين الشريفين للأهلة وعلوم الفلك

د. ياسين محمد المليكي - قسم العلوم الفلكية - كلية العلوم - جامعة الملك عبد العزيز - جدة المملكة العربية السعودية

مقدمة:

يتناول هذا البحث الأسهامات العلمية لمركزخادم الحرمين الشريفين للأهلة وعلوم الفلك. والتي تأتي من منطلق ما توليه حكومة المملكة من إهتمام كبير لتوحيد العالم الإسلامي بتحديد اوائل الشهور الهجرية بدقة عالية من خلال رصد الأهلة وإجراء البحوث العلمية المتعلقة بها. ويتكون المركز من ثلاثة أقسام وهي مركز توقيت مكة المكرمة ، ومعرض الفلك ومركز لأهلة والذييتم التحكم به آليا من خلال شبكة مراصد للأهلة التي تغطي الكرة الأرضية بعدة محطات عالمية وخمس محلية ، مرتبطة بالمركز الرئيس الموجود بساعة مكة المكرمة .حيث سيتم رصد الهلال منذ ولادته ومتابعته لحظة بلحظة ومن خطوط طول مختلفة تغطي الكرة الأرضية .وسيتم رصد الهلال الوليد منذ الإقتران-أي الولادة - مباشرة، سواءا في وضح النهار أو بعد الغروب مباشرة وعند أقل بعد زاوي له من الشمس. كما أن من أهداف المركز ايضا إجراء البحوث المختلفة ذات العلاقة بالأهلة والقمر والشمس من حيث فلكه حول الأرض والشمس من خلال الارصاد السابقة والحالية حسابيا وتقنيا.كما يعرض البحث الدراسات والبحوث الفلكية ذات العلاقة بمركز الفلك والتي تم التعاون على مستوى عالمي في عدة منابع مرتبطة بمادة المركز مثل بحوث الإكسو بلانتس وهو مشروع عالمي بين كل من جامعتي بلجيكا وكمبردج ومركزنا وجامعة القاضي عياض.وهذا المشروع الفريد عالميا يهدف لخدمة الأمة الإسلامية وخدمة العلم ليساهم في انشاء تقويم اسلامي موحد معتبرا مكة المكرمة هي خط الطول الرئيس له والإستمرار في الدور الإسلامي ودوره في تطوير علوم الفلك والتي كان لها دورا كبيرا في القفزات الهائلة في التطور الحالي في علوم الفلك والفضاء .

بالاضافة الى مساهمة مركز توقيت مكه لمنظومة التوقيت العالمي بباريس والتي يتم ميكنة ساعات مكة المكرمة الاربع باشارة من خوادم الساعات الذرية الاحدى عشر، كما تقوم اقسام المركز الثلاثة بعمل الارصاد والبحوث والدراسات من خلال قنوات عالمية لها باع كبير في مجال الرصاد والبحوث .

Lecture **22**

Science at the Universities of the Arabic World

By **Nidhal GUESSOUM**

العلوم في جامعات العالم العربي

نضال قسوم
الجامعة الأمريكية بالشارقة، الإمارات العربية المتحدة

تمثل الجامعات أساس مجتمع المعرفة. وقد تطورت الجامعات في العالم المتقدم على امتداد مئات السنوات لتغدو مؤسسات متخصصة في إنتاج المعرفة ونشرها. أما في العالم العربي، فتمثل الجامعات ظاهرة حديثة نسبياً، إذ أن ثلاثة من كل أربع جامعات عربية تأسست في السنوات الخمس والعشرين الأخيرة من القرن العشرين.

ثمة نظرة جد شائعة ترى أن العلوم في العالم العربي تعاني تأخراً كبيرا، وهذا الرأي يعتمد في الغالب على مؤشرات مثل التصنيف العالمي للجامعات، ومستويات الإنفاق على البحث العلمي، ونسبة عدد الباحثين، وغير ذلك. فعلى سبيل المثال، لا توجد أي جامعة من العالم العربي ضمن المراكز المائة الأولى في التصنيفات العالمية المعروفة، بل ثمة أقل من عشر جامعات عربية ضمن أفضل 400 جامعة في العالم. ولئن كان الإنفاق على البحث العلمي قد ازداد في السنوات الأخيرة، إلا أن كل الحكومات العربي تنفق أقل من 1% من منتوجها على البحث العلمي ، بل معظمها ينفق أقل من 0.5 %، في حين أن المعدل العالمي يبلغ 1.78%، وتنفق معظم بلدان منظمة التعاون الاقتصادي والتنمية (OECD) المتقدمة ما يتراوح بين 2.5 و 3%. ونجد نفس الأمر بشأن عدد الباحثين لكل مليون من عدد السكان.

أما بشأن الإنتاج العلمي (أوراق البحث العلمي المنشورة، براءات الاختراع المسجلة، استشهاد الآخرين بأبحاث علمية منشورة، صادرات التكنولوجيا، الخ) في العالم العربي، فإن ثمة أيضا قناعة واسعة الإنتشار بأن العالم العربي لا يزال جد متأخر عن بقية أنحاء العالم. وقد قامت لجنة خبراء قمت بالتنسيق لها قبل سنتين بتحليل بيانات المنشورات العلمية الصادرة في العالم العربي خلال العقدين الماضيين، 1996 2005، و2006 2015، بهدف تقييم الوضع. وقد نظرت اللجنة أيضا في نسب الاستشهادات العلمية لكل ورقة أو بحث، بالنسبة لكل دولة وفي كل عقد، وذلك قصد قياس جودة الأبحاث العلمية المنشورة. وسأعرض نتائج ذلك كله.

وقد نظرنا أيضا الى وضع المرأة في مجالات العلوم في العالم العربي، سواء الطالبات أو الباحثات، ورغم قلة البيانات بالنسبة لعدة دول، فإن البيانات تشير الى كثرة الطالبات وقلة الباحثات في المجالات العلمية.

إن أهم دور تقوم به الجامعات هو إخراج "منتجات" (خرّيجين) ذات (ذوي) جودة عالية. ومن أجل ذلك يتوجب عليها بذل قصارى جهدها في تحسين أداء التدريس بشكل متواصل. سأحاول تسليط بعض الضوء على مناهج وطرق تدريس العلوم في جامعاتنا وتقديم توصيات بشأن ذلك.

أخيرا وليس آخرا، ثمة واجب هام للجامعات هو نشر الثقافة والوعي في المجتمع بشكل عام، وهنا نلاحظ غياباً كبيراً جدا لأساتذة الجامعات، خاصة في العلوم. وفي ظل هذا الغياب، يبقى المجتمع ضحية لأناس غير مؤهلين على التواصل مع المجتمع بشأن مواضيع هامة لا يملكون خبرة كافية فيها، الأمر الذي يؤدي أحياناً إلى تقديم معلومات خاطئة للمجتمع ينجم عنها اضطرابات وفوضى (مثلما يحدث في حالة وقوع الزلازل، أو ظواهر الكسوف والخسوف، أو الأوبئة، الخ). ومما يدعو للأسف أن جامعاتنا عموما تنظر إلى التواصل مع المجتمع على أنه نشاط هامشي، فلا تشجع الأساتذة على القيام به وتلح فقط على نشر الأوراق البحثية، مما أدى الى ظهور آفات كبرى في ذلك. ولا بد أن يُنظر إلى التواصل مع المجتمع على أنه شكل هام من أشكال الخدمة الأكاديمية (إلى جانب التدريس والبحث) ضمن الواجبات الموكلة إلى أعضاء هيئة التدريس.

سأحاول إذن في هذا المحاضرة التطرق الى كل هذه الجوانب من الموضوع، إذ تحتاج جامعاتنا الى النظر بإمعان في أوضاعها...

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The field of optical turbulence has emerged in a theoretical way in the 40's through studies of the physics of turbulence and was then closely related to the development of High Angular Resolution (HAR) techniques in Astronomy, from speckle interferometry to adaptive optics with all its current developments, including very long baseline optical interferometry. At the J. L. Lagrange laboratory, the set of thematics developed in optical turbulence, is carried out by a team with a unique expertise at the national and international levels, in particular in the field of the site qualification for astronomy. Prof. Aziz Ziad is the head of the « optical turbulence modeling and instrumentation » team of H. Fizeau laboratory. This team gathers know-hows in the wavefront propagation in turbulent media, atmospheric physics linking the geophysical flows to optical turbulence, site-testing experiments based on well calibrated instruments, and a great expertise in real time programming allowing to develop software packages for data acquisition and processing, simulation and modeling. This expertise allowed this team to participate in the selection of the major sites of all the greatest projects of existing telescopes in particular of the 8-10 meter class : GranTeCan in the Canary Islands, the European VLT and Southern Gemini in Chile, Keck, Northern Gemini and Subaru in Hawaii. With a unique set of instruments to probe

atmospheric turbulence, our team was also involved in the site selection for the future ELT telescopes as the 40m European E-ELT and the $30m$ American TMT. Our team was also involved in the qualification of the site of Dome C in Antarctica whose future potential is considerable.

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Jean-Marc Conan is a senior scientist in the High Angular Resolution team of the Optics group of Onera, the French Aerospace Lab. He has worked for more than 20 years on techniques aiming at reaching the diffraction limit of optical instruments despite the presence of aberrations. His main research activity concerns the correction of atmospheric turbulence by adaptive optics (AO) for large astronomical telescopes. He has participated to several AO system studies for ESO Very Large Telescope (NAOS, SPHERE), and for the future European Extremely Large Telescope (MAORY, HARMONI, MOSAIC). His major publications are focused on : characterization of turbulence optical effects, optimal control for AO, wide field tomographic AO and deconvolution of AO corrected images. He also currently explores other applications that benefit from the above mentioned background : impact of turbulence on ground-space optical links for either high data rate optical telecommunications or high precision frequency transfer ; AO for ophthalmology (human retina imaging and surgery) ; AO for 2 photon microscopy (in vivo calcium imaging of the mouse brain activity). His research activities benefit from fruitful collaborations with several institutes : French astronomical observatories (LAM, Paris Obs., Nice-Lagrange...), Institut d'Optique (IOGS), GEMINI, Institut de Neurobiologie de la Méditerranée (INMED), Institut Fresnel, Hôpital des Quinze-Vingts...

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Wisconsin, and others). In June 2003, he was awarded the 2nd Research Prize in Sciences, Engineering, and Architecture at his university. In addition to his academic work, he writes about issues related to science, education, the Arab world, and Islam. Guessoum is also a columnist for Gulf News and The Huffington Post, and has made notable contributions to Nature Middle East. With a number of publications (including a notable book on the subject), he has recently become a prime scholar on the relations between Islam and modern science.

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Professor Abdelmjid Benhida graduated (PHD) in a physics of the sensors from (USTL) the university of Montpellier and Cadi Ayad university of Marrakech. He's an astrophysics researcher in Cadi Ayyad University department of physics in Marrakech since 1991. In 2006, he works on site testing field with the LPHEA laboratory team, what allow Morocco to be selected for the site study campaign for the European Extremely Large Telescope (EELT). At present, he is making Spectro-photometry observations of variable stars at the Oukaimeden Observatory. He's a member of the « Association d'Astronomie Amateur de Marrakech » (3AM), a cultural association aiming to promote science of the universe towards the large public audience (Scholars in particular).

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Ahmed Daassou graduated (PHD) in astrophysics from Cadi Ayyad university of Marrakech. He continues his research in several fields in astrophysics : detection and modeling of the atmosphere of exoplanets, detection and analysis of lunar flashes, photometric and spectroscopic study of meteors, stellar occultation by small solar system body...

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Martin Aubé is a a world leading researcher in the field of remote sensing and modeling of light pollution. He got his Ph.D. degree in remote sensing from Université de Sherbrooke and a M.Sc. degree in astrophysics from Université Laval. He is a physics professor at Cégep de

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