University of Crete
Department of Physics
Section of Astrophysics & Space Physics

Annual Report for 2014

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Image Credit of Cover Page
Top: View of the Skinakas summit with the telescope domes and the housing quarters (see Sect. 3.1).
Middle: The receiving antennae of the SESCAT experiment near Chania (see Sect. 3.2).
Bottom: The 1.3m telescope of Skinakas Observatory inside its dome (see Sect. 3.1).

1. INTRODUCTION

The present document summarizes the activities of the members of the Section of Astrophysics and Space Physics at the Department of Physics of the University of Crete, during the 2014 calendar year. The staff of the Section consisted of 13 PhD research scientists, 13 graduate students and 4 technicians. Members of the Section were involved in teaching undergraduate and graduate courses at the University of Crete, while doing research in the fields of Theoretical and Observational Astrophysics, as well as in Atmospheric and Ionospheric Physics. Their research has been funded by national and international research grants, and in 2014 it resulted in 60 papers published in refereed journals, that is 4.6 papers per PhD researcher. Significant efforts were also devoted in the operation and improvement of the infrastructure and hardware at Skinakas Observatory and the Ionospheric Physics Laboratory. This document was prepared in January 2014, based on contributions from all members of the Section. The final editing was done by V. Charmandaris.

2. PERSONNEL

2.1. PERSONNEL OF THE SECTION

The staff associated with the Section of Astrophysics and Space Physics consists of 13 PhD research scientists, 8 PhD students, 5 Master's students, and 4 technicians.

The 9 Physics faculty members of the Section during the period of the report were Vassilis Charmandaris (Prof.), Christos Haldoupis (Prof.), Nikolaos D. Kylafis (Prof.), John Papamastorakis (Emeritus Prof.), Iossif E. Papadakis (Prof.), Vasiliki Pavlidou (Assist. Prof.), Kostas Tassis (Assist. Prof.), Ilias M. Vardavas (Assoc. Prof.) and Andreas Zezas (Assist. Prof.). Pablo Reig (Principal Researcher at the Foundation for Research and Technology – Hellas) is also affiliated with the Section. Researchers in non-tenure track positions holding a PhD degree were Dr. Dmitry Blinov, Dr. Laure Ciesla, and Dr. Eleni Vardoulaki. Support staff associated with the Skinakas Observatory were Mr. Anastasios Kougentakis, Dr. Eythymios V. Paleologou, Mr. George Paterakis, and Ms. Anna Stiakaki.

PhD students during this period were Konstantina Anastasopoulou (with A. Zezas), Tassos Epitropakis (with I. Papadakis), Ioannis Liodakis (with V. Pavlidou), Alexandros Maragkoudakis (with A. Zezas), Grigoris Maravelias (with A. Zezas), Alexandros Psychogyios (with V. Charmandaris), Gina Panopoulou (with K. Tassis), Charalampos Politakis (with A. Zezas), and Aris Tritsis (with K. Tassis).

Master's students were Angelos Nersesian (with P. Reig) from the class of 2013, while from the class of 2014 were Ioannis Komis, Foteini Mylonaki, Ioanna Psaradaki, and Dimitris Tanoglidis.

2.2. PERSONNEL CHANGES AND NOTABLE EVENTS

In September 2014, Associate Professors V. Charmandaris and I. Papadakis were promoted to Professors, while Prof. C. Haldoupis retired after 37 years of service to the Department of Physics.

K. Anastasopoulou (BSc Univ. of Patras, MSc Univ. of Munich), I. Liodakis (BSc & MSc Univ. of Patras), G. Panopoulou (BSc & MSc Univ. of Crete), C. Politakis (BSc

Univ. of Patras, MSc Univ. of Crete) and A. Tritsis (BSc Univ. of Ioannina, MSc Univ. College London) joined the PhD program of the Department.

Prof. A. Zezas was awarded a highly competitive ERC consolidator grant entitled "Accreting Binary Populations in Nearby Galaxies: Observations and Simulations" with a total budget of 1,242,000 Euros.

Prof. V. Pavlidou was awarded one of the three 2014 L'OREAL-UNESCO Women in Science awards. The award recognizes scientific excellence among Greek female scientists up to 38 years old, who work in the fields of life sciences and natural sciences.

2.3. Graduating Students

Mr. Grigoris Maravelias succefully defended his PhD in Astrophysics in September 2014. His thesis, performed under the supervision of Prof. Zezas, was entitled "Investigation of the high-mass X-ray binary populations in the small Magellanic cloud". Dr. Maravelias moved to a postdoctoral fellow position at the Astronomical Institute, Academy of Sciences of the Czech Republic,

Ms. Gina Panopoulou succefully defended her Master's Thesis in Astrophysics in March 2014. Her thesis, performed under the supervision of Prof. Tassis, was entitled "Study of the filamentary structures in the Taurus molecular cloud". Ms. Panopoulou was subsequently enrolled to the PhD program of our Departement under the supervision of Prof. Tassis.

3. Facilities

3.1. Skinakas Observatory

The Skinakas Observatory operates as part of a scientific research collaboration between the University of Crete and the Foundation for Research and Technology-Hellas (FORTH[1]). Faculty and staff of the Section, using the facilities of Skinakas, are also affiliated members of the Institute of Electronic Structure and Laser (IESL[2]) of FORTH. IESL provides additional hardware and logistics support towards the research of the members.

Only the 1.3 m telescope was fully operating at Skinakas Observatory in 2014. This telescope is a Modified Ritchey-Chrétien telescope with a 1.3 m aperture (focal ratio of f/7.6), which was built by DFM Engineering and Zeiss and became operational in 1995. The 30 cm telescope (focal ratio f/3.2) was also operating, but for a limited time period. A number of modern instruments are permanently available on the 1.3 m telescope. These include several optical CCD cameras with complete filter sets, a long slit optical spectrograph, a high resolution (R=38,000) echelle spectrograph, as well as a near-IR wide field camera.

The RoboPol Collaboration, consisting of the Skinakas Observatory, the California Institute of Technology (USA), the Inter-University Center for Astronomy and Astrophysics (India), the Max-Planck Institute for Radio Astronomy (Germany), and

[1] For more information on FORTH visit: http://www.forth.gr
[2] For more information on IESL visit: http://www.iesl.forth.gr

the Nicolaus Copernicus University (Poland), continued the normal operations of RoboPol, a novel-design optical polarimeter mounted on the 1.3 m telescope of Skinakas Observatory. The main scientific aim of this collaboration is the study of the optical polarization of blazars and other transients, as well as of the mapping of magnetic fields in the interstellar medium.

The main projects during the 2014, April-to-November, observing period were:

- Photometry, Spectroscopy, and Polarimetry of Binaries with a compact star companion
- Near-infrared observations of HMXB and nearby galaxies
- Optopolarimetric monitoring of gamma-ray--loud blazars and other active galactic nuclei
- Magnetic field mapping of interstellar clouds using absorption-induced optical polarization of light from background stars

The tradition of "open nights" continued and the Observatory was open to the public for 5 nights, from May until September 2014. They were very successful, with a "full-house" capacity each night.

More details on Skinakas Observatory, the quality of the site, the telescopes, and the available instrumentation can be found in its recenty updated web page at: http://skinakas.physics.uoc.gr

3.2. Ionospheric Physics Laboratory

The Ionospheric Physics Laboratory (IPL), in collaboration with Stanford University, continued the un-interrupted operation of a narrow-band very low frequency (VLF) receiver experiment throughout 2014, and maintained its VLF database. This experiment is used for studying VLF signatures and propagation effects in the lower ionosphere during times of intense atmospheric electrical activity and the occurrence of transient luminous events (sprites and elves) in the upper atmosphere.

4. Courses

A number of elective undergraduate and graduate courses, directly related to the research areas covered by the Section, were offered as part of the teaching responsibilities of the faculty members. For the caldendar year 2014 these were:

- Spring Semester 2014
  - "Astrophysics II"
  - "Astrophysics III"
  - "Production and Transfer of Radiation"

- Fall Semester 2014
  - "Astrophysics I"
  - "Atmospheric Environment"
  - "Evolution of Planetary Atmospheres"
  - "High Energy Astrophysics"
  - "Reduction and Analysis of Astronomical Observations"

5. SCIENTIFIC RESEARCH

Here we present a brief description of the major research projects in which members of the Section were involved in 2014. These are grouped by research area and the scientists associated with each project are indicated in parentheses.

The scientific publications that resulted from this work, over the same period, are presented at the end of the report in section 12.

5.1. THEORETICAL ASTROPHYSICS

- Black-hole X-ray binaries: Over the past several years, a rich phenomenology has been accumulated regarding black-hole X-ray binaries. When the sources are in the, so-called, hard X-ray state, a compact jet is always present. In the, so-called, soft X-ray state, no jet is ever detected. In the hard-to-soft transition, the jet disappears eruptively, while in the soft-to-hard transition the jet reappears in a smooth way. All this phenomenology has been explained with a physical model and only one free parameter, the mass-accretion rate. (Researcher involved: N. Kylafis).

- Anomalous X-ray pulsars: Extremely interesting observations have been made recently on the hard X-ray spectra of Anomalous X-ray Pulsars (AXPs). The hard X-rays have luminosity comparable to that of the soft X-rays and they are pulsed, with the rotational period of the neutron stars involved. The pulsed fraction of the hard X-rays increases with the energy of the photons and it becomes ~100% at ~100 keV. In addition, the pulse shape changes with X-ray energy. A model to explain all of the above, plus the pulsed radio emission observed in some of them, has been worked out. (Researchers involved: N. Kylafis, A. Zezas).

- Simulations of Galactic star-forming regions: non-equilibrium chemodynamical multi-fluid non-ideal MHD simulations of star-forming molecular cloud cores. Identification of observable quantities (such as molecular species ratios) that can distinguish between theories of star-formation. Calibration of frequently used molecular species (such as OH for Zeeman observations) for measurement of magnetic fields. (Researchers involved: K. Tassis, A. Tritsis)

- Sources of the gamma-ray background: Modeling of astrophysical populations that may be contributing to the diffuse gamma-ray sky, such as star-forming galaxies, blazars, and millisecond pulsars. Development of techniques to decompose different contributions to the gamma-ray background and to identify possible exotic signals, such as an annihilation signature from dark-matter subhalos in the Galaxy (Researchers involved: I. Liodakis, V. Pavlidou)

- Spectral formation in radiative shocks: X-ray pulsars are accreting magnetic neutron stars. Accretion of matter onto a magnetic neutron star results in a radiative shock in the accretion column. Spectral formation in such a radiative shock is a rather difficult problem to solve, because of the large optical depths involved. In low-luminosity X-ray pulsars, on the other hand, the problem becomes tractable. A Monte Carlo calculation was performed and the computed spectrum is quite similar to that observed from low-luminosity pulsars. The results may be applicable to Anomalous X-ray Pulsars accreting matter from a

fallback disk. (Researcher involved: N. Kylafis).

- Star formation in the simulated Universe: development of realistic star-formation algorithms for cosmological simulations in order to connect the dark matter halos with the observable universe. The developed algorithms follow the formation of molecular hydrogen and molecular clouds, where stars are known to form in the local universe. (Researchers involved: K. Tassis)

- Large-scale Structure Formation in the Universe: The formation of large-scale structure in the Universe is a cosmic battle between expansion inertia, gravity, and the accelerating influence of dark energy. Using analytic and semi-analytic calculations we follow the formation and growth of structure under different cosmologies. In universes with dark energy, the ultimate fate of structure formation is the halting of structure growth -- a state which can leave observable imprints in the mass-radius relations of local-universe structures such as groups and clusters of galaxies. (Researchers involved: V. Pavlidou)

- Astrostatistics: Application of statistical methods in astrophysical problems. Recent projects include: assessing the significance of apparent correlations between average AGN fluxes at different wavelengths, derivation of star-formation histories from colour-magnitude diagrams, derivation of LogN-LogS distributions accounting for selection effects and biases, modeling of the 2D surface brightness of galaxies, development of adaptive smoothing methods for feature detection, activity classification of galaxies using multi-dimentional optical and multi-wavelength diagnostics, derivation of spectral parameters from X- ray hardness ratios (Researcher involved: A. Zezas as member of the California/Harvard/ASC Astrostatistics Collaboration, V. Pavlidou).

5.2. Observational Astrophysics

5.2.1. Observational Galactic Astrophysics

- X-ray variability of X-ray binaries (XRB): BHB consist of a black hole orbiting a regular star. When part of the material from the optical companion is accreted on the compact object the system brightens in X-rays. Hard X-ray observations provide a valuable probe of the emission region near the compact object. One of the main features of the environment in the vicinity of the black hole is the iron emission line at 6.4 keV. The goal here is to study the relationship between the line parameters with other observables (mass accretion rate, hardness of the spectrum). We employ advance timing techniques, such as, time lags, Fourier-resolve spectroscopy, and power spectrum analysis (Researchers involved: P. Reig, I. Papadakis).

- Characterization of the variability time scales in Be/X-ray binaries (BeX): BeX consist of a neutron star orbiting a O9e-B2e main-sequence star. The letter "e" stands for emission, as instead of the normal photospheric absorption lines the optical spectra of Be stars display emission lines. Strong infrared emission is another defining characteristic of Be stars. A third observational property is that the light from a Be star is polarized. The origin of these three observational properties (emission lines, infrared excess, and polarization) lies in a gaseous, equatorially concentrated circumstellar disc around the OB star. This disc constitutes the main source of variability in BeX and the fuel that powers the X-

ray emission through accretion. The main objective of this project is to characterize the optical/IR variability time scales of Be/X-ray binaries in correlation with their X- ray activity. Another goal of this project is to investigate the effects of the compact object on the structure and evolution of the circumstellar envelope. One of the most interesting effects is the truncation of this envelope by the neutron star. In this project we wish to find observational evidence of such a truncation using the three most important techniques in Astronomy: photometry, spectroscopy and polarimetry. (Researchers involved: P. Reig, A. Zezas)

- Study of the aperiodic variability of X-ray pulsars during giant outbursts. The main goal of this project is the definition and unified characterization of accretion-powered pulsar spectral states during giant outbursts. In the last twenty-five years, the discovery of different "states" in the X-ray emission of black-hole binaries (BHB) and neutron-star Low-Mass X-ray Binaries (LMXBs) constituted a large step forward in the understanding of the physics of accretion onto compact objects. While there are numerous studies on the timing and spectral variability of BHB and LMXBs, very little work has been done on High- Mass X-ray Binaries (HMXBs). We have found that Be/X-ray pulsars trace two different branches in the hardness-intensity diagram: the horizontal branch corresponds to a low-intensity state of the source and it is characterised by fast colour and spectral changes and high X-ray variability. The diagonal branch is a high-intensity state that emerges when the X-ray luminosity exceeds a critical limit. The two branches may reflect two different accretion modes, depending on whether the luminosity of the source is above or below a critical value. This critical luminosity is mainly determined by the magnetic field strength, hence it differs for different sources. The details of this work can be found in Reig & Nespoli (2013, A&A, 551, A1). (Researchers involved: P. Reig)

- Ultraluminous X-ray sources (ULXs) in nearby galaxies. A subset of ultraluminous X-ray sources (those with luminosities of less than $10^{40}\,\mathrm{erg\,s^{-1}}$) are thought to be powered by the accretion of gas onto black holes with masses of ~5–20 $M_{\odot}$. The X-ray and radio emission are coupled in such Galactic sources; the radio emission originates in a relativistic jet thought to be launched from the innermost regions near the black hole, with the most powerful emission occurring when the rate of infalling matter approaches a theoretical maximum (the Eddington limit). Only four such maximal sources are known in the Milky Way. We have performed radio and X-ray observations of a bright new X-ray source in the nearby galaxy M 31, whose peak luminosity exceeded $10^{39}\,\mathrm{erg\,s^{-1}}$. The radio luminosity is extremely high and shows variability on a timescale of tens of minutes, arguing that the source is highly compact and powered by accretion close to the Eddington limit onto a black hole of stellar mass. Continued radio and X-ray monitoring of such sources should reveal the causal relationship between the accretion flow and the powerful jet emission. Studies of more distant galaxies allow us to investigate the population of ULXs in the context of the less luminous XRB populations. Such studies, particularly in the case of galaxies with vigorous star-formation, indicate that the majority of ULXs are the upper end of the luminosity distribution of the "regular" XRB populations. (Researchers involved: P. Reig, A. Zezas)

- Polarization studies of the Interstellar Medium: After suffering absorption by

interstellar cloud dust, starlight may become polarised if the dust grains have a preferential alignment induced by the interstellar magnetic field. Studies of this polarisation with the RoboPol instrument can reveal the magnetic field structure in interstellar clouds, giving important clues about the role of magnetic fields in the star formation process. (Researchers involved: G. Panopoulou, K. Tassis, D. Blinov)

5.2.2. OBSERVATIONAL EXTRAGALACTIC ASTROPHYSICS

- Study of X-ray sources in the Small Magellanic Cloud: A systematic study of the X-ray source populations in the Small Magellanic Cloud is underway, using deep Chandra observations of regions of the Small Magellanic Cloud sampling different stellar populations (a Chandra X-ray Visionary Program). Supporting optical imaging and spectroscopic data obtained with the 6m-Magellan Telescope (IMACS), the 4m-Anglo-Australian Telescope (AOmega), and the VLT (VIMOS), are used to characterize the X-ray sources and identify the X-ray binaries. The goal of this study is to measure the formation efficiency of X-ray binaries as a function of age, and compare it with higher metallicity galaxies such as the Large Magellanic Cloud and our Galaxy. (Researchers involved: A. Zezas).

- X-ray source populations in nearby galaxies: Studies of the discrete X-ray source populations (in particular accreting sources) in nearby galaxies and their connection with their parent stellar populations (star-formation history, metallicity, etc) and star-cluster parameters. Studied objects cover the full spectrum of galaxies, ranging from dwarf-irregular star-forming galaxies to spiral and elliptical galaxies. Recently these studies were supplemented by imaging observations of nearby galaxies above 10 keV with NuSTAR. These observations allow us to measure for the first time the integrated hard X-ray emission of galaxies and compare it with their star-formation activity, as well as detect and characterize individual X-ray sources. Key in this effort is the development of diagnostics for the characterization of the accretion state of X-ray binaries detected in NuSTAR observations. (Researchers involved: K. Anastasopoulou, Ch. Politakis, A. Zezas).

- Extragalactic supernova remnant populations: Multiwavelength studies of the supernova remnant populations in nearby galaxies using data from the Chandra X-ray observatory and narrow-band data from the Skinakas observatory. The goal of this project is to understand the populations of SNRs in different wavelengths in a variety of environments (Researchers involved: A. Zezas).

- X-ray variability studies of AGN: Work on the study of the variability properties of the iron line in bright Seyferts, and the study of the "reverberation", negative time lags at high frequencies in a few AGN, using XMM-Newton data, was continued. We have spent a significant amount of time in the study of the statistical properties of the observed time lags in AGN. The work is almost finished, and should be published soon. The project regarding the energy dependence of the X-ray power-spectra of a few bright AGN is really completed, using XMM-Newton light data. The publication of the results is delayed, but should materialize early next year. The collaboration with colleagues from the Astronomical Institute of the Academy of Sciences of the Czech Republic continued. Work on the theoretical "response" functions of

accretion discs to X-ray flashes from "point-like" X-ray sources was intensified and the results should be published soon. (Researchers involved: I. Papadakis, A. Epitropakis).

- Optopolarimetric monitoring of Active Galactic Nuclei: The polarisation properties of the optical (synchrotron) emission from blazers and other AGN encodes important information about the magnetic field configuration in the relativistic jet powering these systems. Using the RoboPol polarimeter, the optopolarimetric properties of about 100 AGN are regularly monitored throughout the Skinakas observing season - the largest-scope such effort in the world today. (Researchers involved: D. Blinov, G. Panopoulou, V. Pavlidou, I. Papadakis, N. Kylafis, K. Tassis, P. Reig)

- Multiwavelength studies of interacting galaxies: This is a comprehensive study of a large sample of interacting galaxies with the Spitzer Space Telescope and the Chandra X-ray Observatory. The goal of this study is to address the connection between galaxy interactions and induced star-formation and AGN activity, and to use these results to test simulations of galaxy interactions (Researchers involved: A. Zezas).

- A census of star-forming activity in the local Universe (the Star-formation Reference Survey): This is a systematic study of the star-formayion and AGN activity in a representative sample of IR-selected galaxies in the local Universe. The main goal of this project is to investigate the connection between galactic activity (star formation and AGN) and galactic parameters such as stellar mass, dust content, and morphology. First results from this effort include a mass function of disks and bulges in the local Universe (P. Bonfini's PhD thesis), and a census of AGN activity in local galaxies (Maragkoudakis et al, in prep). (Researchers involved: A. Zezas, A. Maragkoudakis)

- Mid-/Far-infrared and radio continuum properties of Luminous and Ultraluminous Infrared Galaxies (LIRGs/ULIRGs): This project was based on observations with the Spitzer Space Telescope in order to explore the mid-infrared properties of ULIRGs. The main goal is to improve our understanding of the dominant mechanism of the energy source (accretion onto an active nucleus or a super-massive starburst) in these galaxies and ascertain their role in galaxy evolution. There are various components of this project. One major component is the characterization of the mid- and far-infrared emission for a complete flux-limited sample of local LIRGs/ULIRGs, the Great Observatories All-Sky Survey (GOALS) galaxy sample, using the Spitzer and Herschel Space telescopes. A second is the analysis of the radio continuum observations of a GOALS subsample obtained with the VLA and explore the connection between the radio and infrared emission. In addition analysis of the role of LIRGs/ULIRGs at high redshift is being conducted based on date obtained with the Herschel Great Observatories Origins Deep Survey (H-GOODS). (Researchers involved: V. Charmandaris, E. Vardoulaki).

- UV to near-IR morphology of Luminous and Ultraluminous Infrared Galaxies (LIRGs/ULIRGs): This project was based on observations with the Hubble Space Telescope of the Great Observatories All-Sky Survey (GOALS) galaxy sample. Its main goal is to develop a consistent morphological classification of these local systems in order to study the evolution of similar galaxies at high-z. (Researchers involved: V. Charmandaris, A. Psychogyios).

- The Spectral Energy Distribution (SED) of distant Infrared Galaxies: This project involved the development and application of state-of-the-art SED fitting models, and in particulate CIGALE in order to understand the power source in high-z galaxies detected in deep extragalactic surveys, in order to quantify the contribution of the elusive Compton thick AGN. (Researchers involved: L. Ciesla, V. Charmandaris).

- Star formation and stellar populations in Hickson Compact Groups: This project is based on mid- and far-infrared observations of a sample of Hickson Compact Groups obtained with the Spitzer Space Telescope and Herschel Space Observatory. Additional near-infrared imaging data of the Palomar 5m telescope, and Skinakas 1.3m telescope are being used in order to map in detail the star formation activity and old stellar population of these systems. The analysis was extended to a larger sample of ~1700 compact galaxy groups identified in the Sloan Digital Sky Survey, with ancillary data of GALEX and WISE (Researchers involved: V. Charmandaris).

5.3. Atmospheric & Ionospheric Physics

- Earth Observation and climate Project: Research work on Earth Observation and the Earth's Radiation Budget is an ongoing project. Modelling work of the radiation forcing of aerosols on a planetary scale includes the effects of aerosols on the solar ultraviolet, visible and near-infrared radiation reaching the Earth's surface. Model input data include satellite data from the NASA EOS satellites, Aqua and Terra. Ground-based data include the AERONET (Aerosol Robotic Network) site operated in Crete and provided by NASA Goddard. Climate research includes the effects of the El Nino phenomenon on the surface radiation budget over the tropical Pacific ocean. Collaboration with NASA Langley and the Meteorological Institute of the University of Munich on the heat budgets of enclosed seas, such as the Mediterranean, Black and Red seas is ongoing.: (Researchers involved: I. Vardavas).

- Modelling the Evolution of Planetary Atmospheres Project: Research on modelling the evolution of planetary atmospheres has focussed on the development of a radiative/convective-photochemical-microphysical model for the global mean vertical atmospheric structure of the Precambrian Earth and of Titan. The Titan model has been validated against data from the recent Cassini/Huygens mission to Titan. A model for the formation of the haze layer that surrounds Titan has been developed. Work on the evolution of ultraviolet and XUV radiation of G-type solar like stars, which affects the atmospheric chemical composition of planets orbiting such stars, is ongoing with planned applications to exoplanets around G-type stars. (Researchers involved: I. Vardavas)

- Ionospheric and Upper Atmospheric Physics: The research topics under study relate to the plasma physics and electrodynamics of irregular ionosphericphenomena occurring at midlatitude, and problems associated with the interaction and coupling of the neutral mesosphere and lower thermosphere with the earth's ionosphere. During 2014 our research focused on the following topics : 1) the properties and mechanisms relating to the formation and destabilization of midlatitude sporadic E plasma layers (Es), and the role of

wind shears and atmospheric tidal, gravity and planetary waves on sporadic E layer morphology and variability. 2) the effects on VLF (very low frequency) electromagnetic wave propagation and VLF response signatures associated with "transient luminous events", such as sprites, elves and gigantic jets, which are atmospheric electricity (thunderstorm and lightning) phenomena in the upper atmosphere and lower ionosphere; modelling the lifetimes of lightning-produced VLF peturbations, 3) meteor trail plasma instabilities and unusually long-lasting meteor echoes observed with VHF (very high frequency) and HF radars, 4) studies of ionospheric resonance phenomena observed in ultra low frequency (ULF) electromagnetic noise recordings with sensitive coil magnetometers, and 4) studies of the annual and seasonal variations of midlatitude sporadic E layers, and 5) Effects of X-ray solar flare events on the lower ionosphere using Arecibo radar incoherent scatter measurements. (Researchers involved: C. Haldoupis).

6. RESEARCH FUNDING

The following projects, funded by national and international agencies, enabled the research activities of the Section during the period of the report.

- EU funded International Research Staff Exchange Scheme Grant for the "The Physics of The Most Luminous Galaxies", (P.I.: V. Charmandaris, budget: €171,800, duration: 2012-2016)
- Marie Curie Career Integration Grant "JetPop", entitled "Unveiling the Physics of the Most Active of Galaxies: Using Blazars as Laboratories to Study Supermassive Black Holes and Relativistic Jets", (P.I.: V. Pavlidou, budget: €100,000, duration: 2012-2016)
- Marie Curie International Reintegration Grant "SFOnset", entitled "Onset of Star Formation: Connecting Theory and Observations Coupling Dynamics and Interstellar Chemistry in Molecular Cloud Cores", (P.I.: K. Tassis, budget: €100,000, duration: 2012-2016)
- ESPA Postdoctoral Fellowship Grant entitled "The Radio Continuum Properties of Luminous Infrared Galaxies", (P.I.: V. Charmandaris / E. Vardoulaki, budget: €150,000, duration: 2012-2015)
- GSRT-Funded "Excellence" (Aristeia I) Grant "RoboPol", entitled "Unveiling the physics of supermassive black holes and relativistic jets with optical polarization of blazars", (P.I.: V. Pavlidou, budget: €330,000, duration: 2012-2015)
- GSRT-Funded "Excellence" (Aristeia II) Grant entitled "The quest for relativistic signals in the X-ray lightcurves of AGN", (P.I.: I. Papadakis, budget: €134,000, duration: 2014-2015)
- ERC Consolidator Grant "A-Bingos", entitled " Accreting Binary populations in Nearby Galaxies: Observations and Simulations", (P.I.: A. Zezas, budget: €1,242,000, duration: 2014-2019)

7. Collaborations with Other Institutes

Members of the group are actively collaborating with scientists affiliated with the following universities and research institutes:

- Greece
  - Foundation for Research and Technology – Hellas (FORTH), Heraklion
  - National Observatory of Athens, Athens
  - Technical Education Institute of Crete, Dept. of Electrical Engineering, Heraklion
  - University of Athens, Dept. of Physics, Athens
  - University of the Aegean, Dept. of Environment, Mytilene
  - University of Ioannina, Dept. of Physics, Ioannina

- International
  - California Institute of Technology, Pasadena, CA, USA
  - CEA/Saclay, Service d'Astrophysique, Paris, France
  - Eötvos-Lenard University, Budapest, Hungary
  - ETH, Zurich, Switzerland
  - Geophysical Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria
  - Harvard University, Center for Astrophysics, Cambridge, MA, USA
  - Hebrew University of Jerusalem, Jerusalem, Israel
  - Imperial College London, UK
  - Institut d'Astrophysique de Paris, France
  - Intra-University Centre for Astronomy and Astrophysics, Pune, India
  - Max-Planck-Institut für Astronomie, Heidelberg, Germany
  - Max-Planck-Institut für Extraterrestrische Physik, Garching, Germany
  - Max-Planck-Institut für Kernphysik, Heidelberg, Germany
  - Max-Planck-Institut für Radioastronomie, Bonn, Germany
  - NASA Goddard Space Flight Center, Greenbelt, MD, USA
  - NASA Jet Propulsion Laboratory, Pasadena, CA, USA
  - NASA Langley Division of Atmospheric Sciences, Langley, VA, USA
  - Nicolaus Copernicus Astronomical Center, Warsaw & Torun, Poland
  - Northwestern University, Evanston, IL, USA
  - Observatoire de Geneve, Geneva, Switzerland
  - Observatoire de Paris, Paris, France
  - Oxford University, Oxford, UK
  - Rome Observatory, Rome, Italy
  - Shanghai Astronomical Observatory, Shanghai, China
  - Stanford University, Palo Alto, CA, USA
  - Université de Rennes, Rennes, France
  - University of Alicante, Alicante, Spain
  - University of Durham, Durham, UK
  - University of Diego Portales, Santiago, Chile
  - University of Illinois at Urbana-Champaign, USA
  - University of Maryland, College Park, MD, USA
  - University of Napoli Federico, Napoli, IL
  - University of Saskatchewan, Canada
  - University of Southampton, Southampton, UK
  - University of Texas at Austin, Austin, TX, USA
  - University of Valencia, Valencia, Spain

8. National & International Committees

During the period covered by this report, members of the Section were in a number of national and international committees. More specifically:

Prof. V. Charmandaris continued his duties as the Editor of the European Astronomical Society Newsletter (since 2005) as well as substitute member of the Greek National Committee for Astronomy. From September 2013 he is serving as the Director of the Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing of the National Observatory of Athens.

Prof. N. Kylafis is serving as the President of Greek National Committee for Astronomy, as well as a member of the Council of the Univ. of Crete for the 2013-2017 term. His second term as the President of the Hellenic Astronomical Society ended in June 2014.

Prof. I. Papadakis ended his second term as the Secretary of the Hellenic Astronomical Society in June 2014. He also served as Chair to the pannel of the 2014 NASA/ADAP Committee.

Dr. P. Reig was elected member of the governing council of the Hellenic Astronomical Society. He also participated in the Observing Time Allocation Committee of the XMM-Newton AO14 call.

Prof. I. Vardavas is on the Editorial Board of the Environmental Modelling and Software Journal.

9. Conference & Workshop Organization

Prof. J. Papamastorakis was the chair of the organizing committee of the "Onassis Foundation Science Lecture Series", which take place at the premises of FORTH every summer. The lectures are principally sponsored by the Onassis Benefit Foundation and selected students from across Europe are financially assisted to attend. A Nobel laureate as well as other leading scientists in the same field, present intensive lectures to students for a week. Typically one or two lecture series are organized every summer since 2001. The 2014 lectures in Chemistry and Biology were addressing the topic of "Molecular Conformational Fluctuations: Origins of Biological Specificity and Applications in Pharmacochemistry" (see http://www.forth.gr/onassis).

The 3rd Workshop of the RoboPol collaboration (see Section 3.1) took place at the FORTH premises on 22-24 April 2014.

10. Public Outreach

All members of the Section are involved in a number of public outreach activities throughout the year. These consist of giving public lectures, mostly in the island of Crete, along with dedicated tours to the facilities of Skinakas Observatory, as well as TV and radio interviews. The group also supports the activities organized by the local amateur astronomical societies in Crete, and by the secondary education career center.

11. VISITORS

A total of **30** scientists visited our Department during the 2014 calendar year in order to collaborate with staff members of the Section and/or give seminars. These individuals were: Prof. S. Ando (Univ. of Amsterdam, The Netherlands), Dr. E. Angellakis (MPIfR Bonn, Germany), Dr. V. Antoniou (CfA, Harvard Univ., USA), Dr. P. Bonfini (Swinburne Univ., Australia), Prof. A. Bourdillon (Univ. of Rennes 1, France) Dr. M. Dovciak (Astronomical Inst. of the Academy of Sciences, Czech Republic), Dr. D. Elbaz (CEA/Saclay, France) Dr. T. Hovatta (Caltech, USA), Ms S. Varsha Imrith (Queen Mary Univ. of London, UK), Ms K. Wai Fun Lam (Queen Mary Univ. of London, UK), Prof. P. Kalas (Univ. of California, Berkeley, USA), Dr. S. Kiehlmann (MPIfR Bonn, Germany), Dr. O. King (Caltech, USA), Prof. K. Kokkotas (Univ. of Tubingen, Germany), Dr. B. Lehmer (NASA/GSFC, USA), Prof. M. Milgrom (Weizmann Institute, Israel), Mr. I. Myserlis (MPIfR Bonn, Germany), Prof. T. Mouschovias (Univ. of Illinois at Urbana-Champaign, USA), Dr. F. Nicastro (Rome Obs., Italy),), Dr. E. Ntormousi (CEA/Saclay, France), Ms B. Pazderska (Nicolaus Copernicus University, Poland), Dr. T. Pechacek (Astronomical Inst. of the Academy of Sciences, Czech Republic), Prof. T. Prodanovic (Univ. of Novi Sad, Serbia), Mr. C. Schreiber (CEA/Saclay, France), Dr. A. Słowikowska (Univ. of Zielona Gora, Poland), Dr. J.-L. Starck (CEA/Saclay, France), Dr. O. Straub (Obs. de Paris – LUTH, France), Dr. F. Tamborra (Obs. de Strasbourg, France), Prof. J. Trumper (MPE-Garching, Germany), Ms V. Varta (Geodetic and Geophysical Inst., Sopron, Hungary).

12. PUBLICATIONS

The following **60** publications of the members of the Section appeared in print in international refereed journals (according to ISI/WoS) during the 2014 calendar year. This corresponds to **4.6** refereed publications per PhD researcher. For each publication, the names of the members of the Section are underlined.

1. Ackermann, M., Ajello, M., Allafort, A., Antolini, E., Barbiellini, G., Bastieri, D., Bellazzini, R., Bissaldi, E., Bonamente, E., Bregeon, J., Brigida, M., Bruel, P., Buehler, R., Buson, S., Caliandro, G.A., Cameron, R.A., Caraveo, P.A., Cavazzuti, E., Cecchi, C., Chaves, R.C.G., Chekhtman, A., Chiang, J., Chiaro, G., Ciprini, S., Claus, R., Cohen-Tanugi, J., Conrad, J., Cutini, S., D'Ammando, F., De Palma, F., Dermer, C.D., do Couto e Silva, E., Donato, D., Drell, P.S., Favuzzi, C., Finke, J., Focke, W.B., Franckowiak, A., Fukazawa, Y., Fusco, P., Gargano, F., Gasparrini, D., Gehrels, N., Giglietto, N., Giordano, F., Giroletti, M., Godfrey, G., Grenier, I.A., Guiriec, S., Hayashida, M., Hewitt, J.W., Horan, D., Hughes, R.E., Iafrate, G., Johnson, A.S., Knoedlseder, J., Kuss, M., Lande, J., Larsson, S., Latronico, L., Longo, F., Loparco, F., Lovellette, M.N., Lubrano, P., Mayer, M., Mazziotta, M.N., McEnery, J.E., Michelson, P.F., Mizuno, T., Monzani, M.E., Morselli, A., Moskalenko, I.V., Murgia, S., Nemmen, R., Nuss, E., Ohsugi, T., Orienti, M., Orlando, E., Perkins, J.S., Pesce-Rollins, M., Piron, F., Pivato, G., Porter, T.A., Raino, S., Razzano, M., Reimer, A., Reimer, O., Sanchez, D.A., Schulz, A., Sgro, C., Siskind, E.J., Spandre, G., Spinelli, P., Stawarz, L., Takahashi, H., Takahashi, T., Thayer, J.G., Thayer, J.B., Thompson, D.J., Tinivella, M., Torres, D.F., Tosti, G., Troja, E., Usher, T.L., Vandenbroucke, J., Vasileiou, V., Vianello, G., Vitale, V., Werner, M., Winer, B.L., Wood, D.L., Wood, K.S., Aleksic, J., Ansoldi, S., Antonelli, L.A., Antoranz, P., Babic, A., Bangale, P., de Almeida,

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