



UNIVERSITY OF CRETE
DEPARTMENT OF PHYSICS
SECTION OF ASTROPHYSICS & SPACE PHYSICS

ANNUAL REPORT FOR 2009

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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 2009 calendar year. The staff of the Section consisted of 18 PhD research scientists, 4 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 2009 it resulted in 40 papers published in refereed journals, that is 2.2 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 2010, 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 18 PhD research scientists, 4 graduate students, and 4 technicians.

The 8 Physics faculty members of the Section during the whole period of the report were Vassilis Charmandaris (Assoc. Prof.), Christos Haldoupis (Prof.), Despina Hatzidimitriou (Assoc. Prof.), Nikolaos D. Kylafis (Prof.), John Papamastorakis (Emeritus Prof.), Iossif Papadakis (Assoc. Prof.), Ilias M. Vardavas (Assoc. Prof.) and Andreas Zezas (Assist. Prof.). David Burrows (visiting Professor), Pablo Reig (Researcher B' at the Foundation for Research and Technology – Hellas) and Fotis Mavromatakis, (Assist. Prof. at the Technical Educational Institute of Heraklion) were also affiliated with the Section. Researchers in non-tenure track positions holding a PhD degree were Dr. Elisabete da Cunha, Dr. Tanio Díaz-Santos, Dr. Omaira Gonzales-Martin, Dr. Fabrizio Nicastro, Dr. Kostas Pavlakis, Dr. Agnieszka Slowikowska, and Dr. Malgosia Sobolewska. Support staff associated with the Skinakas Observatory were Anastasios Kougentakis, Dr. Eythymios V. Paleologou, George Paterakis, and Anna Stiakaki.

PhD students during this period were Nikos Benas (with I. Vardavas), Theodore Bitsakis (with V. Charmandaris), and Paolo Bonfini (with A. Zezas). Haralambos Politakis was a Masters student in Astrophysics (with A. Zezas). In September 2009, three new Masters students - Evaggelia Koutra, Maria Tsantaki and Alexandros Psychogios - commenced the 2009-2010 Masters program in Astrophysics.

2.2. PERSONNEL CHANGES

T. Díaz-Santos and O. Gonzales-Martin joined the group in March 2009 and August 2009 respectively, as research associates under European Union grants. D. Burrows (Penn State Univ., USA) was appointed Visiting Professor. V. Charmandaris was promoted to Associate Professor. J. Papamastorakis retired in August 2009 and became Emeritus Professor.

D. Hatzidimitriou was on sabbatical in the Spring of 2009, and formally moved to the Univ. of Athens in September 2009, where she has been elected as an Associate Professor. Dr. A. Slowikowska completed her postdoctoral appointment and moved to a postdoctoral position at the Kepler Institute of Astronomy, of the University of Zielona Gora, Poland. Dr. M. Sobolewska also completed her postdoctoral appointment and moved to the Harvard Smithsonian Center for Astrophysics, Cambridge, MA (USA).

2.3. GRADUATING STUDENTS

Mr. Haralambos Politakis obtained his Masters in Advanced Physics with specialty in "Astrophysics and Space Physics" in November 2009. His Masters thesis, performed under the supervision of Prof. Zezas, was entitled "Photoionization models of active galactic nuclei (AGN)"

3. FACILITIES

3.1. SKINAKAS OBSERVATORY

The Skinakas Observatory operates as part of a scientific research collaboration between the University of Crete, the Foundation for Research and Technology-Hellas (FORTH¹) and the Max-Planck-Institut für Extraterrestrische Physik in Germany. Faculty and staff of the Section using the facilities of Skinakas, are also affiliated members of the Institute of Electronic Structure and Laser (IESL²) of FORTH. IESL provides additional hardware and logistics support towards the research of the members.

The Observatory has two fully operating telescopes. One 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 second is a 0.6 m Cassegrain telescope (focal ratio of f/8) owned by the University of Tübingen (Germany) and co-operated with the Univ. of Crete, which is remotely controlled in a robotic mode via the web. A third 30 cm telescope (focal ratio f/3.2) is also available and was used in a few projects during the 2009 observing season.

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 main projects during the 2009 April-to-November observing period were:

- ❑ Photometry and Spectroscopy of Planetary Nebulae and SNe Remnants.
- ❑ R-band and H α monitoring of the central region of M31 for the discovery and follow-up photometry of new Novae.
- ❑ Photometry and Spectroscopy of Binaries with a compact star companion.
- ❑ Near-infrared observations of HMXB
- ❑ High speed photo-polarimetry of optical GRB afterglows
- ❑ High photo-polarimetry of X-ray binaries (HMXR, microquasars)
- ❑ Fast Photometry of cataclysmic variables

¹ For more information on FORTH visit: <http://www.forth.gr>

² For more information on IESL visit: <http://www.iesl.forth.gr>

The High Time Resolution OPTIMA Instrument ("OPTIMA BURST"³) of the Max-Planck Institut für Extraterrestrische Physik was successfully installed at the 1.3 m telescope and was in operation for the months of June and July 2009.

The tradition of "open nights" continued and the Observatory was open to the public for five nights during the 2009 observing season. The Observatory also participated in various events associated with the International Year of Astronomy, sponsoring – among other activities - a series of lectures that took place in the city of Heraklion through out the year. In addition, during a day dedicated to the IYA 2009 the Observatory was open for the public of the region and a series of public outreach talks were presented at the village of Anogia.

More details on the Observatory, the quality of the site, the telescopes, and the available instrumentation can be found at: <http://skinakas.physics.uoc.gr>

3.2. IONOSPHERIC PHYSICS LABORATORY

The Ionospheric Physics Laboratory (IPL), maintained operation of its main experimental facility, SESCAT (Sporadic E SCATter experiment), during the summer of 2009. SESCAT, which is the only ionospheric scatter radar that exists in Greece, operates at 50 MHz mostly as a Doppler radar but occasionally also as radio interferometer. It is observing magnetic aspect radio backscatter from electrostatic plasma waves in the E region of the ionosphere during times of strong dense layers of metallic ions, which form at altitudes of ~100 km and are subject to plasma instabilities. In addition, IPL in collaboration with Stanford University, continued (since 2003) the un-interrupted operation of a narrow-band very low frequency (VLF) receiver experiment throughout 2008, 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. Also, since the summer of 2005, IPL operates, in collaboration with the Eötvös-Lenard Budapest University, a second automatic VLF receiver system on a routine basis side by side with the Stanford receiver in the rooftop of the Physics Building. In 2007, a new GPS (Global Positioning System) receiver station was set up in Crete (in collaboration with the Universite de Rennes, France) for continuous monitoring of the ionospheric variability by measuring total electron content and S4 index changes. E and F region EM coupling studies using joint SESCAT and GPS observations are planned for the near future.

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 academic year 2008 these were:

- SPRING SEMESTER 2009
 - "Astrophysics II"
 - "Production and Transfer of Radiation"
 - "Introduction to Atmospheric Physics"
 - "Physics of Galaxies"

³ For more information on "Optima" visit: <http://www.mpe.mpg.de/OPTIMA>

- FALL SEMESTER 2009
 - "Astrophysics I"
 - "Astrophysics III"
 - "Atmospheric Environment"
 - "Evolution of Planetary Atmospheres"
 - "Observational Cosmology"

5. SCIENTIFIC RESEARCH

Here we present a brief description of the major research projects in which members of the Section were involved in 2009. 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 11.

5.1. THEORETICAL ASTROPHYSICS

- Black holes as X-ray sources: Modeling of the spectral states of black-hole X-ray binaries in order to explain their energy spectrum (from radio to X-rays) and the intricate time variability of their intensity. Compton up-scattering of soft photons in the jet seems to be the mechanism for producing the hard X-ray spectrum and the variability observed. (Researchers involved: N. Kylafis, P. Reig)
- Anomalous X-ray pulsars: Extremely interesting observations have been made recently on the hard X-ray spectrum of Anomalous X-ray Pulsars (AXPs). The hard X-rays have luminosity comparable to that of the soft X-rays and it is pulsed, with the rotational period of the neutron stars involved. In addition, the pulse fraction of the hard X-rays increases with the energy of the photons and it becomes $\sim 100\%$ at ~ 100 keV. A model to explain all of the above, plus the pulsed radio emission observed in some of them, has been worked out and it is in the final stages of preparation for submission for publication. (Researcher involved: N. Kylafis)
- Time-Evolving Photoionization: Updating and upgrading our in-house time-evolving photoionization code, to include: (a) portability (FITS-IO interface routines allowing general photo-ionizing light-curves, Spectral Energy Distributions, Ionization-Balance inputs, and output spectral fitting with the fitting package "Sherpa" of the Chandra Interactive Analysis of Observations - CIAO - software); (b) detailed time-evolving population level computation; (c) inclusion of fine-structures transitions for low-ionization metals, and (d) approximated radiative transfer computation. (Researchers involved: F. Nicastro)
- Astrostatistics: Application of statistical methods in astrophysical problems. Recent projects include: derivation of star-formation histories from colour-magnitude diagrams, analysis of data taking into account calibration uncertainties, derivation of spectral parameters from X-ray hardness ratios (Researchers involved: A. Zezas as member of the California/Harvard/ASC Astrostatistics Collaboration).

- Modeling the Spectral Energy Distribution of Galaxies: We use the code developed by da Cunha et al. 2008 in order to model in detail the complete spectral energy distribution (SED) of galaxies from the UV to the sub-mm. The code is applied in a variety of samples drawn from well known surveys (such as GOODS, H-ATLAS, and SDDS) in order to derive physical connection between the dust and star formation properties in these systems. (Researchers involved: E. da Cunha and external collaborators).

5.2. OBSERVATIONAL ASTROPHYSICS

5.2.1. OBSERVATIONAL GALACTIC ASTROPHYSICS

- X-ray variability of X-ray binaries (XRB): XRB consist of a compact star (neutron star or 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. The goal here is to study their spectral and timing properties. Last year, we analysed the RXTE data from the 2005/2006 outburst of GRO J1655 and of the 1996-1999, 2002-2003 and 2004-2005 outbursts of GX 339-4. We have fitted hundreds of spectra with phenomenological and more physical models, and we have also characterized the observed flux variations with the use of traditional power and cross-spectral techniques. The results from this project are expected to be published next year (Researchers involved: P. Reig, I. Papadakis, M. Sobolewska)
- Optical/IR monitoring of 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. The origin of these two observational properties (emission lines and infrared excess) resides 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 truncation. (Researchers involved: P. Reig, A. Zezas)
- Search for non-radial pulsations in Be/X-ray binaries: One of the unsolved issues regarding the physics of Be stars is the ultimate mechanism that originates the circumstellar disc. Rotation was identified as an important feature of the central star, and which may be a significant contributor to the generation of the circumstellar medium. There is no general consensus about whether Be stars rotate close to critical velocity (when the centrifugal force counterbalances the gravitational force at the equator) although latest studies indicate that the mean rotation rate of Be stars is 70%-80% of the critical value. Rapid variability (< 3.5 d) of B and Be stars can be explained as the consequence of non-radial pulsations or a rotational modulation. However,

many studies support the notion that short-term photometric and spectroscopic variability is due to nonradial pulsation. The goals of this project are: i) to investigate the role of the nonradial pulsations in driving mass loss from Be stars, ii) compare the periods with those of Be/X in other galaxies and iii) compare the periods with those of isolated Be stars (Researchers involved: P. Reig)

- Polarization from an exoplanetary atmospheres: Looking for polarized scattered light from an exoplanetary atmospheres. More than 330 extrasolar planets were discovered by indirect method of Doppler spectroscopy, photometric transits, microlensing, and pulsar timing. Polarization measurements allow detecting directly starlight that is scattered in the planetary atmosphere. The scattered light is linearly polarized perpendicular to the scattering plane. It possesses the information on the planetary atmosphere geometry, chemistry, and thermodynamics. During the OPTIMA-Burst campaign at Skinakas Observatory we performed the polarimetric observations of stars that host transiting planets. The goal is to obtain polarization characteristics of the target with very high time resolution as a function of orbital phase of the planet. (Researchers involved: A. Slowikowska)
- Search for optical periodic and quasi-periodic oscillations in High Mass X-ray Binaries by using high-speed photometer OPTIMA. Virtually all HMXB are X-ray pulsars. Pulsations come as a result of the misalignment of the rotation axis and the magnetic axis. Some HMXB also show QPO which are believed to be associated with the inner parts of the accretion disk. In this project we wish to investigate whether pulsations and QPO are also seen in the optical band and study the aperiodic optical variability. (Researchers Involved: P.Reig, A.Slowikowska).

5.2.2. OBSERVATIONAL EXTRAGALACTIC ASTROPHYSICS

- Study of X-ray sources and novae in M31: In collaboration with W. Pietsch and V. Burwitz (MPE/Germany) as well as the XMM-Newton -M31 consortium, we are performing an extensive study of the population of X-ray sources and novae in M31. Spectroscopy of optical counterparts has been obtained with the 1.3m Skinakas Telescope, and the 3.5m telescope at the Apache Point Observatory. Two new XMM-Newton projects have been recently awarded time to pursue this work in 2009 (D. Hatzidimitriou, P. Reig, P. Bonfini)
- Study of X-ray sources in the Small Magellanic Cloud: A study of the X-ray population in the Small Magellanic Cloud is underway, using Chandra observations of the central region of the Small Magellanic Cloud, dominated by a recent burst of star formation. Study of the optical counterparts and characterization of the star formation history in the specific areas of the Chandra sources, has been conducted using optical imaging and spectroscopy with the 6m-Magellan Telescope, and the 4m-Anglo-Australian Telescope (2df). Moreover, XMM-Newton time has been awarded (end of 2008) to an international team (PI: Frank Haberl – MPE), of which DH is a member, for the detailed study of the SMC X-ray binary population (Researchers involved: D. Hatzidimitriou, V. Antoniou, 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. (Researchers involved: A. Zezas, P. Bonfini).

- RR-Lyrae variables in the Small Magellanic Cloud: Derivation of metal abundances ($[Fe/H]$) of 472 RR-Lyrae variables of RRab type in the Small Magellanic Cloud (SMC), based on extended and merged data provided by the OGLE II and OGLE III projects. Fourier decomposition of the 11-year V-band light curves of the variables and Monte Carlo simulations have been used to derive Fourier parameters which are related to $[Fe/H]$. (Researchers involved: D. Hatzidimitriou, E. Kapakos (MSc student, University of Athens), I. Soszynski (Warsaw University Observatory, Poland)).
- 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; this is the PhD project of I. Leonidaki (NOA, University of Patras))
- X-ray variability study of AGN: The results from the Fourier resolved analysis, in the soft X-ray band, of archival XMM data is progressing, albeit with a slow pace. Results should be published (hopefully) next year. The results from the study of the spectral variability of a large sample of nearby AGN, on time scales of months/years, using archival RXTE Data, was completed and published this year. As for the data analysis of the long XMM look on PKS 0548-508, the first paper (where we present the results from the spectral analysis of the data) is already accepted for publication, while the second paper on the timing analysis of the X-ray light curves will be completed soon. Furthermore, a "peculiar" absorption line detected in the RGS spectrum of the source may be associated with a WHIM filament. New projects initiated include the spectral variability study of a large sample of AGN using archival XMM (mainly) data (Researchers involved: I. Papadakis, M. Sobolewska, F. Nicastro, O. Gonzales-Martin).
- The Warm Hot Intergalactic Medium: a) Selection of an optimal UV and X-ray sample for WHIM studies with current - Chandra-LETG and XMM-Newton RGS - and future - HST-COS, IXO and dedicated X-ray WHIM missions like Xenia or Pharos. The selection is based on the brightness of the X-ray sources, $F(0.1-2.5 \text{ keV}) > 4 \times 10^{-12} \text{ ergs/s/cm}^2$, the Galactic column of hydrogen, $N_H < 3 \times 10^{20} \text{ cm}^{-2}$, the target redshift ($z > 0.3$) and the UV brightness ($\lambda F_\lambda(1400\text{\AA}) > 1 \times 10^{-12} \text{ ergs/s/cm}^2$). b) Extensive spectral simulation with current and future X-ray facilities (particularly IXO) of the Warm-Hot Intergalactic Medium along randomly selected lines of sight from the latest hydro-dynamical simulation for the formation of structures in the Universe. Main aim of this work is to perform feasibility studies and establish the optimal technical parameters for upcoming WHIM-dedicated or general-observatory X-ray missions. c) Analysis of the X-ray, FUSE and IUE data of the Narrow Line Seyfert 1 galaxy PKS 0558-504, where we tentatively detect a serendipitous WHIM filament with both metal and HI lines. The detection has a combined (X-Ray+FUSE+IUE) statistical significance of 5.2-sigma, and, if confirmed, represents the first detection of the bulk of the WHIM mass for which a metallicity estimate is possible. We measure a metallicity of few percent solar. Results from this work have been

summarized in a paper, which we submitted recently to the ApJ. d) 2 Point Angular Correlation Function (2-PACF) analysis of the Chandra- and XMM-COSMOS field, in narrow energy band centered around the K-alpha triplets of the main He-like metals (O, Ne and Mg), and comparison of this analysis with hydrodynamical simulations of these field that include WHIM. The aim of this analysis is to extract a residual indirect WHIM signal from the data, and evaluate through simulation the statistical significance of this signal. We also use these narrow-band XMM and Chandra images to cross-correlate with galaxy structure in the COSMOS field, at selected redshifts, with the aim of extracting a signal of direct WHIM emission correlated with Large-Scale Structures. This research is being performed together with colleagues at the MPE in Munich (Germany) and the 3rd University of Rome in Rome (Italy). (Researchers involved: F. Nicastro)

- AGN Warm Absorbers and Feedback: Analysis of XMM-Newton and Chandra LETG data of the Ionized outflows in the Seyfert 1 galaxies (PKS 0558-504, NGC5548, and NGC4051), and study of their AGN-galaxy and AGN-IGM feedback contribution. (Researchers involved: F. Nicastro, Y. Krongold (CfA/Harvard, USA))
- Gamma Ray Bursts: a) Study of the multi-epoch high-resolution optical spectra of Gamma-Ray Burst (GRB) optical afterglows, aimed to measure the distance and the physical state (density, temperature, ionization degree, etc.) of the associated absorbing material along the line of sight, from the GRB. This study has made extensive use of our Time-Evolving Photoionization code and was mainly based on the observed opacity changes in the fine-structure lines of FeII. b) Study of the soft X-ray (0.1-2.5 keV) LogN-LogF (i.e. number of sources N with soft X-ray fluence >F: fluence = Flux * Time) of all Gamma-Ray Burst triggered by the high-energy wide-field Swift detector BAT and followed up in the soft X-rays with the Swift XRT detector. (Researchers involved: F. Nicastro, M.L. Conciatore (CfA/Harvard, USA))
- 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-forming and AGN activity (Researchers involved: A. Zezas).
- Mid-infrared properties of Luminous and Ultraluminous Infrared Galaxies (LIRGs/ULIRGs): This project uses mostly observations of the Infrared Spectrograph as well as the cameras IRAC and MIPS on the Spitzer Space Telescope in order to explore the mid-infrared properties of ULIRGs. The main goal is to improve the understanding of the dominant mechanism of the energy source (accretion onto an active nucleus or a super-massive starburst) in these galaxies. There are various components of this project. One major component is the characterization of the extended mid-infrared emission for a complete flux-limited sample of local LIRGs/ULIRGs - the Great Observatories All-Sky Survey (GOALS) galaxy sample - in order to further establish a connection between low and high redshift infrared luminous systems. Substantial effort is also being devoted in the theoretical modeling of the spectral energy distribution of ULIRGs dominated by star formation, using the code of da Cunha et al. 2008. Preparatory work for the implications of this work in upcoming observations off deep surveys with the Herschel Space Telescope is being

conducted. (Researchers involved: V. Charmandaris, E. da Cunha, T. Díaz-Santos)

- Star formation and stellar populations in Hickson Compact Groups: This project is based on mid-infrared observations of a sample of Hickson Compact Groups obtained with the Infrared Space Observatory and the Spitzer Space Telescope. Additional near-infrared imaging data of the Palomar 5 m 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. (Researchers involved: T. Bitsakis, 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, N. Hatzianastassiou (Univ. of Ioannina), C. Matsoukas (Univ. of the Aegean), K. Pavlakis, A. Fotiadi, C. Papademas (Univ. of Ioannina)).
- 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, P. Lavvas)
- Ionospheric and Upper Atmospheric Physics: The research topics under study relate to the plasma physics and electrodynamics of irregular ionospheric phenomena occurring at midlatitude, and problems associated with the interaction and coupling of the neutral mesosphere and lower thermosphere with the earth's ionosphere. During 2009 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 electrodynamic coupling between the unstable Es plasma and midlatitude ionospheric "spread F" and the generation of large electric fields in patchy sporadic E plasma layers, 3) the role of plasma density gradients on the generation of short scale electrostatic plasma waves in the ionospheric E region, 4) the effects on VLF (very low frequency) electro-

magnetic wave propagation and VLF response signatures associated with "transient luminous events", such as sprites and elves, which are atmospheric electricity (thunderstorm and lightning) phenomena in the upper atmosphere and lower ionosphere; modelling the lifetimes of lightning-produced VLF perturbations, 5) meteor trail plasma instabilities and unusually long-lasting meteor echoes observed with VHF (very high frequency) and HF radars, and 6) studies of ionospheric resonance phenomena observed in ultra low frequency (ULF) electromagnetic noise recordings with sensitive coil magnetometers, and 7) studies of the annual and seasonal variations of midlatitude sporadic E layers, and 8) Effects of X-ray solar flare events on the lower ionosphere (Researchers involved: C. Haldoupis, N. Christakis, N. Ambrosiadi, and A. Mika)

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 Transfer of Knowledge grant for the "Development of an Astrophysics Center in Crete", (P.I.: N.D. Kylafis, budget: €741,000, duration: 2006-2010)
- ❑ EU funded FP7 Programme grant for the "Development of Space Astrophysics in Crete", (P.I.: N.D. Kylafis, budget: €1,120,000, duration: 2008-2011)
- ❑ EU funded FP7 Programme grant "COSMOS", (P.I.: I. Papamastorakis, budget: €110,000, duration: 2008-2009)
- ❑ ESA funded project on the "Support to Development of a Standard Product Generation Pipeline and a Quality Control Framework for Data Products within the Advanced Data Processing System for Herschel", ESA/Herschel Mission. (P.I.: V. Charmandaris, budget: €271,000, duration: 2006-2009)
- ❑ John Latsis Foundation Grant: "Water Resources of Greece under Climatic Change", (P.I. I. Vardavas, budget: €40,000, duration: 2008-2010)
- ❑ Marie Curie International Reintegration Grant: (P.I.: A. Zezas, budget: €100,000, duration: 2008-2011)

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 the Aegean, Dept. of Environment, Mytilene
 - University of Ioannina, Dept. of Physics, Ioannina
- ❑ INTERNATIONAL
 - Anglo-Australian Observatory, Australia
 - California Institute of Technology, Spitzer Science Center, Pasadena, CA, USA
 - CEA/Saclay, Service d'Astrophysique, France
 - Cornell University, Astronomy Department, Ithaca, NY, USA
 - Danish Space Research Institute (DSRI), Denmark

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- Eötvös-Lenard University, Budapest, Hungary
 - ETH, Zurich, Switzerland
 - Free University of Berlin, Germany
 - Geophysical Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria
 - Harvard University, Center for Astrophysics, Cambridge, MA, USA
 - Imperial College, UK
 - Institut d'Astrophysique de Paris, France
 - Institute of Physics of the Earth, Russia
 - Lawrence Livermore National Lab, CA, USA
 - Leiden Observatory, Leiden, The Netherlands
 - Max-Planck-Institut für Extraterrestrische Physik, Garching, Germany
 - Max-Planck-Institut für Kernphysik, Heidelberg, Germany
 - Miami University, Oxford, OH, USA
 - NASA Goddard Space Flight Center, Greenbelt, MD, USA
 - NASA Langley Division of Atmospheric Sciences, Langley, VA, USA
 - NASA Marshall Space Flight Center, Huntsville, AL, USA
 - National Space Science and Technology Center, Huntsville, AL, USA
 - Nicolaus Copernicus Astronomical Center, Warsaw & Torun, Poland
 - Observatoire de Paris, France
 - Royal Observatory Edinburgh, UK
 - San Diego State University, CA, USA
 - Stanford University, Palo Alto, CA, USA
 - Tel Aviv University, Israel
 - Université de Rennes, France
 - University of Alicante, Spain
 - University of Arizona, Tucson, AZ, USA
 - University of Durham, Durham, UK
 - University of Oulu, Finland
 - University of Saskatchewan, Canada
 - University of Southampton, UK
 - University of Texas at Austin, Austin, TX, USA
 - University of Valencia, Spain
 - University of Zielona Gora, Kepler Institute of Astronomy, Poland
 - Warsaw University Observatory, Poland

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 is serving as the Secretary of the Hellenic Astronomical Society for a second term (2008-2010). He continued his duties as the Editor of the European Astronomical Society Newsletter (since 2005), and the Editor of the Newsletter of the Hellenic Astronomical Society (since 1997).

Prof. C. Haldoupis, is serving as an Associate Editor of the Journal of Geophysical Research (JGR), of the American Geophysical Union (2006-2009). He also served as Guest Editor for a special issue of *Annales Geophysicae*, on the results presented at the 12th International Symposium on Equatorial Aeronomy, published in 2009 by the European Geosciences Union.

Prof. D. Hatzidimitriou is the President of the IAU Commission 37: "Star Clusters and Associations" for the 2009-2012 term. She is also a member of the organising committee of the IAU Commission 37.

Prof. N. Kylafis was an ordinary member of the Greek National Committee for Astronomy (GNCA) and a substitute to the representative of Greece to the Optical Infrared Coordination Network for Astronomy (OPTICON). He is also serving as the Dean of the School of Sciences of the Univ. of Crete for the 2008-2012 term.

Prof. J. Papamastorakis was a substitute member of the Greek National Committee for Astronomy.

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 two and occasionally three lecture series are organized every summer since 2001. The 2009 lectures in Biology were addressing the topic of "Immunobiology" (see <http://www.forth.gr/onassis>).

10. VISITORS

A total of 29 scientists visited our Department during the 2009 calendar year in order to collaborate with staff members of the Section and/or give seminars. These individuals were: Dr. V. Antoniou (CfA, Harvard Univ., USA), Dr. W. Brinkman (MPE-Garching, Germany), Prof. A. Bourdillon, (Univ. de Rennes, France), Prof. D. Burrows (Penn State Univ., USA), Dr. A. Coustenis (Obs. de Paris, France), Prof. C. Done (Univ. of Durham, UK), Dr. D. Elbaz (CEA/Saclay, France), Dr. D. Emmanoulopoulos (Univ. of Southampton, UK), Dr. B. Groves (Leiden Univ., The Netherlands), Prof. P. Kalas (Univ. of California, Berkeley, USA), Dr. G. Kanbach (MPE-Garching, Germany), Dr. D. Kazanas (NASA/GSFC, USA), Dr. C. Kouveliotou (NASA/MSFC, USA), Dr. E. Le Floch (CEA/Saclay, France), Dr. J. Gutierrez Soto (Instituto de Astrofísica de Andalucía, Spain), Dr. P. Lubinski, (ISDC Versoix, Switzerland), Dr. G. Magdis (CEA/Saclay, France), Dr. O. Malandraki (National Obs. of Athens), Dr. F. Mirabel (CEA/Saclay, France), Prof. T. Mouschovias (Univ. of Illinois at Urbana-Champaign, USA), Dr. N. Prantzis (IAP, France), Dr. C. Raeth (MPE-Garching, Germany), Prof. Y. Terzian (Cornell Univ., USA), Prof. J. Trumper (MPE-Garching, Germany), Dr. V. Pavlidou (Caltech, USA), Dr. K. Tassis (JPL, USA), Dr. P. Uttley (Univ. of Southampton, UK), Dr. M. Woche (MPE-Garching, Germany). Prof. A. Zdziarski, (CAMK Warsaw, Poland).

11. PUBLICATIONS

The following 40 publications of the members of the Section appeared in print in international refereed journals (according to ISI/WoS) during the 2009 calendar year. This corresponds to ~ 2.2 refereed publications per PhD researcher. For each publication, the names of the members of the Section are underlined.

1. Alonso-Herrero, A., Rieke, G., Colina, L., Pereira-Santaella, M., Gracia-Marin, M., Smith, J.D.T., Brandl, B.R., Charmandaris, V., Armus, L., "The Extreme Star Formation Activity of Arp299, revisited", 2009, ApJ, 697, 600
2. Antoniou, V., Hatzidimitriou, D., Zeas, A., Reig, P., "Optical Spectroscopy of 20 Be/X-ray Binaries in the Small Magellanic Cloud", 2009, ApJ, 707, 1080
3. Antoniou, V., Zeas, A., Hatzidimitriou, D., McDowell, J. C., "The Chandra Survey of the Small Magellanic Cloud "Bar". II. Optical Counterparts of X-ray Sources", 2009, ApJ, 697, 1695
4. Armus, L., Mazzarella, J. M., Evans, A. S., Surace, J. A., Sanders, D. B., Iwasawa, K., Frayer, D. T., Howell, J. H., Chan, B., Petric, A., Vavilkin, T., Kim, D. C., Haan, S., Inami, H., Murphy, E. J., Appleton, P. N., Barnes, J. E., Bothun, G., Bridge, C. R., Charmandaris, V., Jensen, J. B., Kewley, L. J., Lord, S., Madore, B. F., Marshall, J. A., Melbourne, J. E., Rich, J., Satyapal, S., Schulz, B., Spoon, H. W. W., Sturm, E., U, V., Veilleux, S., Xu, K., "GOALS: The Great Observatories All-Sky LIRG Survey", 2009, PASP, 121, 559
5. Bernard-Salas, J., Spoon, H. W. W., Charmandaris, V., Leboutellier, V., Farrah, D., Devost, D., Brandl, B. R., Wu, Yanling, Armus, L., Hao, L., Sloan, G. C., Weedman, D., Houck, J. R., "A Spitzer High-resolution Mid-Infrared Spectral Atlas of Starburst Galaxies", 2009, ApJ Sup., 184, 230
6. Bösinger, T., Ermakova, E. N., Haldoupis, C., Kotik, D. S., "Magnetic-inclination effects in the spectral resonance structure of the ionospheric Alfvén resonator", 2009, *Annales Geophysicae*, Volume 27, Issue 3, 2009, pp.1313-1320
7. Bonfini, P., Hatzidimitriou, D., Pietsch, W., Reig, P., "Spectroscopy of the bright optical counterparts of X-ray sources in the direction of M 31", 2009, A&A, 507, 705
8. Boquien, M., Duc, P.-A., Wu, Y., Charmandaris, V., Lisenfeld, U., Braine, J., Brinks, E., Iglesias-Páramo, J., Xu, C. K., "Collisional Debris as Laboratories to Study Star Formation", 2009, ApJ, 137, 4561
9. Boulanger, F., ..., Charmandaris, V., ..., et al. "The Molecular Hydrogen Explorer", 2008, *Experimental Astronomy*, Vol. 23, Issue 1, pp. 277-302
10. Boumis, P., Xilouris, E. M., Alikakos, J., Christopoulou, P. E., Mavromatakis, F., Katsiyannis, A. C., Goudis, C. D., 2009, A&A, 499, 789
11. Branchini, E., Ursino, E., Corsi, A., Martizzi, D., Amati, L., den Herder, J. W., Galeazzi, M., Gendre, B., Kaastra, J., Moscardini, L., Nicastro, F., Ohashi, T., Paerels, F., Piro, L., Roncarelli, M., Takei, Y., Viel, M., "Studying the Warm Hot Intergalactic Medium with Gamma-Ray Bursts", 2009, ApJ 697, 328
12. Brandl, B. R., Snijders, L., den Brok, M., Whelan, D. G., Groves, B., van der Werf, P., Charmandaris, V., Smith, J. D., Armus, L., Kennicutt, R. C., Houck, J. R., "Spitzer-IRS Study of the Antennae Galaxies NGC 4038/39", 2009, ApJ, 699, 1982
13. Brassington, N. J., Fabbiano, G., Kim, D.-W., Zeas, A., Zepf, S., Kundu, A., Angelini, L., Davies, R. L., Gallagher, J., Kalogera, V., Fragos, T., King, A. R., Pellegrini, S., Trinchieri, G., "Deep Chandra Monitoring Observations of NGC 4278: Catalog of Source Properties", 2009, ApJS, 181, 605

14. Christakis, N., Haldoupis, C., Zhou, Q., Meek, C., "Seasonal variability and descent of mid-latitude sporadic E layers at Arecibo", 2009, *Annales Geophysicae*, Volume 27, Issue 3, 2009, pp.923-931
15. Coustenis, A.,... Vardavas, I., ..., et al. "TandEM: Titan and Enceladus mission", 2009, *Experimental Astronomy*, Vol. 23, Issue 1, p. 893
16. D'Elia, V., Fiore, F., Perna, R., Krongold, Y., Covino, S., Fugazza, D., Lazzati, D., Nicastro, F., Antonelli, L. A., Campana, S., Chincarini, G., D'Avanzo, P., Valle, M. Della, Goldoni, P., Guetta, D., Guidorzi, C., Meurs, E. J. A., Mirabel, F., Molinari, E., Norci, L., Piranomonte, S., Stella, L., Stratta, G., Tagliaferri, G., Ward, P., "The Prompt, High-Resolution Spectroscopic View of the "Naked-Eye" GRB080319B", 2009, *ApJ*, 694, 332
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18. Gliozzi, Mario, Papadakis, Iossif E., Eracleous, Michael, Sambruna, Rita M., Ballantyne, David R., Braitto, Valentina, Reeves, James N., "Short-Term Variability and Power Spectral Density Analysis of the Radio-Loud Active Galactic Nucleus 3C 390.3", 2009, *ApJ*, 703, 1021
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20. Guainazzi, M., Risaliti, G., Nucita, A., Wang, J., Bianchi, S., Soria, R., Zeas, A., "AGN/starburst connection in action: the half million second RGS spectrum of NGC 1365", 2009, *A&A*, 505, 589
21. Haldoupis, C., Mika, Á., Shalimov, S., "Modeling the relaxation of early VLF perturbations associated with transient luminous events", 2009, *Journal of Geophysical Research*, Volume 114, Issue 14, CiteID A00E04
22. Hao, Lei, Wu, Yanling, Charmandaris, V., Spoon, H. W. W., Bernard-Salas, J., Devost, D., Lebouteiller, V., Houck, J. R., "Probing the Excitation of Extreme Starbursts: High-Resolution Mid-Infrared Spectroscopy of Blue Compact Dwarfs", 2009, *ApJ*, 704, 1159
23. Keremedjiev, M., Hao, L., Charmandaris, V., "The Mid-Infrared Narrow-Line Baldwin Effect Revealed by Spitzer", 2009, *ApJ*, 690, 1105
24. Kim, D.-W., Fabbiano, G., Brassington, N. J., Fragos, T., Kalogera, V., Zeas, A., Jordán, A., Sivakoff, G. R., Kundu, A., Zepf, S. E., Angelini, L., Davies, R. L., Gallagher, J. S., Juett, A. M., King, A. R., Pellegrini, S., Sarazin, C. L., Trinchieri, G., "Comparing GC and Field LMXBs in Elliptical Galaxies with Deep Chandra and Hubble Data", 2009, *ApJ*, 703, 829
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29. Papadakis, I. E., Sobolewska, M., Arevalo, P., Markowitz, A., McHardy, I. M., Miller, L., Reeves, J. N., Turner, T. J., "A correlation between the spectral and timing properties of AGN", 2009, A&A, 494, 905
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37. Sobolewska, M. A., Papadakis, I. E., "The long-term X-ray spectral variability of AGN", 2009, MNRAS, 399, 1597
38. Spoon, H. W. W., Armus, L., Marshall, J. A., Bernard-Salas, J., Farrah, D., Charmandaris, V., Kent, B. R., "High-Velocity Neon Line Emission From the ULIRG IRAS F00183-7111: Revealing the Optically Obscured Base of a Nuclear Outflow", 2009, ApJ, 693, 1223
39. Tyler, K.D., Le Floch, E., Rieke, G.H., Dey, A., Desai, V., Brand, K. Borys, C., Jannuzi, B.T., Armus, L., Dole, H., Papovich, C., Brown, M.J.I., Blaylock, M., Higdon, S. J. U., Higdon, J.L., Charmandaris, V., Ashby, M.L.N., Smith, H.A., "Spitzer 70/160 μm observations of high-redshift ULIRGs and HyLIRGs in the Boötes field", 2009, ApJ, 691, 1846
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12. CONTACT

The Department of Physics of the University of Crete is located on a campus 8 km west of Heraklion, the largest city in the island of Crete, Greece. At the end of 2009 it consisted of 30 faculty members, as well as a number of research associates and graduate students, working on various fields of theoretical and experimental physics. The postal address of the Section of Astrophysics and Space Physics is:

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