Hipparchos
The Hellenic Astronomical Society Newsletter

Hellenic Astronomical Society

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Message from the President

Dear friends

This issue of HIPPARCHOS marks a turning point in its history, since it is the first issue edited by the new editor, Dr. Kokkotas. Kostas, an elected member himself of the Governing Council of Hel.A.S., succeeds Dr. Manolis Plionis who served with great zeal the last four years as Editor, after Dr. X. Moussas and the first Editor Dr. J. Seiradakis. We wish from this point to thank all of them and especially Manolis Plionis who offered his advice to the new Editor. We all hope that, with your contribution, HIPPARCHOS will stay alive and thriving, as a realistic mirror of the interests, the progress and the achievements of the Greek Astronomers and Astrophysicists around the world.

As you probably know, the Proceedings of the 6th Astronomical Meeting (September 2003) have been published since June, but, unfortunately, we are unable to send the copies to most of you, since each copy has 400 pages of A4 size and its mailing will test the financial situation of our Society. You have probably seen the Proceedings on the webpage of Hel.A.S., but if you want a hard copy please send me an e-mail in order to arrange delivery. I urge all of you who travel to Athens to try to pick up a copy from my office at the University of Athens.

Meanwhile, with the Hel.A.S. Governing Council, we had a first meeting with Dr. N. Solomos, the Local Organizer of the next 7th Astronomical Meeting, which will take place at the beautiful island of Kefallonia next year. The Local Organization looks promising. This month the Governing Council will convene to decide the overall theme of this Meeting as well as the members of the Scientific Committee. In the General Assembly of Hel.A.S. that will take place during the 7th Astronomical Meeting we shall be asked to vote on some realistic changes in the Society's constitution.

I hope that all of you have learned that we plan to publish a new version of the Yearbook of Greek Astronomers (2005). The first issue (1991) was a very successful and useful one for all of us. Please, send me by e-mail your short CV on the stencil that can be found in the webpage of the Society. I shall ask it as a personal favor to forward this stencil to all astronomers or relative scientists whom you know here in Greece and abroad and who are not members of our Society. We shall include in this publication as many scientists as possible, members of Hel.A.S. or not. I have received so far only a handful of answers and I am afraid that this is due to the Greek illness of procrastination! The questionnaire is so simple, you need only few moments to fill it and send it to me. Do it right now!

Another initiative announced in the Newsletters is the English-Greek Dictionary of Astronomical terms. As you probably know many graduate students have a great difficulty in translating in their theses the English terms of our Science. Their supervisors know and use probably only the English terms and they cannot advise these graduate students. I think that the Society can keep a virtual Dictionary on its webpage, where the interested persons ask questions on the English terms they wish to translate and the learned scientists answer with their own translation. There is a chat room in the webpage of the Society and I see already questions without answers. Dr. Charmandaris informs me that many SPAMs have found their way on this page and he has proposed ways to keep the chat room clean. In the meanwhile, please check regularly the page and offer your help. I hope that in the near future I shall be able to collect all the accepted or all the diverse translations and publish them in an English-Greek Dictionary referring at each term the persons who have given the answer. Please, check it now, our graduate students wait for your contribution.

Paul G. Laskarides
President of Hel.A.S.

Inside this issue:

GENERAL ASSEMBLY AND ELECTIONS IN HEL.A.S.

In the elections that followed the 20th General Assembly of June 21, 2004, the members of Hel.A.S. voted for a President, as well as a new Council and Auditors. The ballots were reviewed and counted by a Committee having as members Dr. Mastichiadis, Dr. Akylas and Dr. Dallas. Out of the 254 members of the Society, 96 had paid their annual dues on the day of the elections and were eligible to vote. A total of 89 ballots were collected, 6 of which were not eligible to be considered according to the Constitution. (5 were submitted late and 1 was from a member who had not paid his dues). The results were:

President: Prof. Laskarides Paul (79 votes)

Council:

1. Prof. Tsinganos Kanaris (49 votes)
2. Assoc. Prof. Theodossiou Efstratios (38 votes
3. Assoc. Prof. Moussas Xenophon (31 votes)
4. Assoc. Prof. Kokkotas Kostas (26 votes)
5. Ass. Prof. Hadjidimitriou Despina (22 votes)
6. Dr. Daglis Ioannis (22 votes)
7. Dr. Georgantopoulos Ioannis (20 votes)
8. Dr. Dara Eleni (18 votes)
9. Prof. Geroyannis Vassilios (12 votes)

Auditors:

1. Ass. Prof. Danezis Emmanouil (39 votes)
2. Dr. Xilouris Emmanouil (39 votes)
3. Assoc. Prof. Mavromichalaki Eleni (25 votes)
4. Ass. Prof. Stergioulas Nikolaos (22 votes)
5. Dr. Grammenos Theofanis (16 votes)
6. Dr. Manimanis Vassilios (15 votes)

The composition of the new Governing Council is:

President: Prof. Laskarides Paul
Council: Prof. Tsinganos Kanaris
Assoc. Prof. Theodossiou Efstratios
Assoc. Prof. Moussas Xenophon
Assoc. Prof. Kokkotas Kostas
Assist. Prof. Hatzidimitriou Despina
Prof. Geroyannis Vassilios

Note that according to Article 31 of the Constitution of Hel.A.S., at least 3 out of the 7 members of the Council have to reside outside the Athens metro area. As a result, Prof. Geroyannis (Univ. of Patras) takes the seventh position in the Council even though Dr. Georgantopoulos , Dr. Daglis and Dr. Dara received more votes.

During the first meeting of the new Council on July 8th 2004, Dr. Despina Hatzidimitriou, was appointed vice-president of the Society while Dr. Tsinganos and Dr. Theodossiou remained as Secretary and Treasurer, respectively. Dr. Kokkotas was proposed as the new Editor of Hipparchos, while Dr. Tsinganos and Dr. Charmandaris remained the Editors of the monthly electronic newsletter of the society.

NEW MEMBERS OF HEL.A.S.

- **Members of Hel.A.S. moving from Junior to Ordinary status:**
  Dr. Stamatellos Dimitrios *(Cardiff University, U.K.)*
- **Newly elected Junior members:**
  1. Chatzivantsidis Georgios *(Univ. of Thessaloniki)*
  2. Gerontidou Maria *(Univ. of Athens)*
  3. Giannios Dimitrios *(Univ. of Crete)*
  4. Metallinou Fiori-Anastasia *(Univ. of Thessaloniki)*
  5. Petridis Andreas *(Univ. of Cyprus)*
  6. Plainaki Xristina *(Univ. of Athens)*
- **Newly elected Associate members:**
  Papaioannou Athanasios *(Univ. of Athens)*
- **Members Deceased:**
  Dr. Polygiannakis John

EDITOR'S COMMENT

Dear Colleagues,

Recently I have been assigned by the Governing Council of ELASET the responsibility of editing Hipparchos, the Journal of our Society. Hipparchos took its present shape, thanks to the hard work of the previous editors J.H. Seiradakis, X. Mousas and M. Plionis. I will do my best to maintain the high standards set by them and to keep Hipparchos as a friendly whiteboard for the Greek astronomers.

In future issues, I plan to include, in the form of reviews, the scientific achievements of all Greek groups as well as reviews on currents issues by Greeks working abroad.

I encourage submission of articles on issues related to funding of basic research, short and long term priorities in the Greek Astronomy and the teaching of Astronomy in the High-Schools and Universities. I welcome suggestions on improving the quality of Hipparchos and I ask you to be prepared to write your own contribution.

KDK

FIRST LIGHT **of the 2.3-m ARISTARCHOS telescope**

The National Observatory of Athens and the telescope constructing company Carl Zeiss Jena GmbH installed the 2.3-m ARISTARCHOS telescope on the Helmos Astronomical Station. The installation of the heavy parts of the telescope (infrastructure, Altazimuth mount, telescope tube) commenced on June 2003. The rest of the telescope components (M1, M2, and AGU) were integrated on site last summer and we obtained the first light of the telescope on September 15, 2004. This was a major milestone of the project, which is now at its final stage. Since then, the commissioning is going on in order to meet the specifications of the telescope (image quality, pointing accuracy, tracking performance, etc).

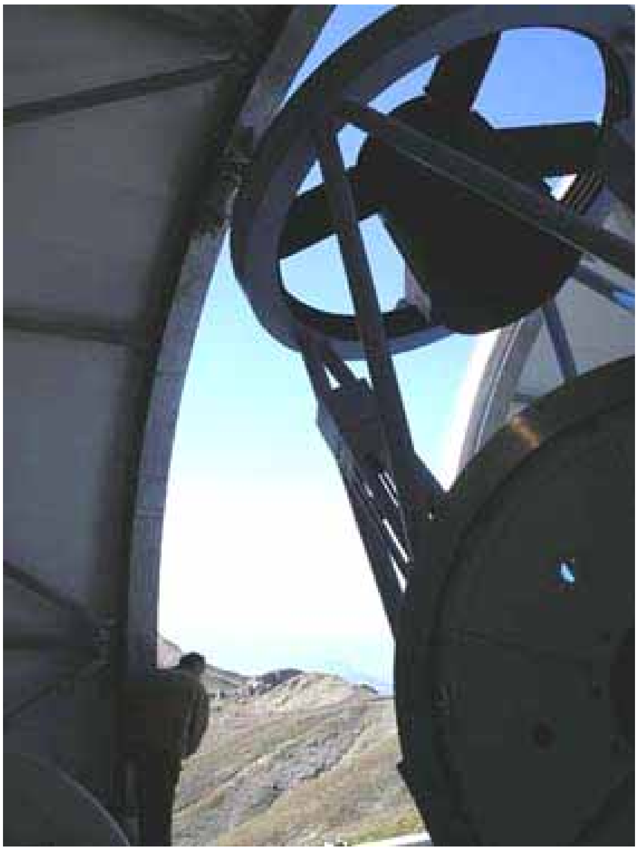


***Figure 1:** The ARISTARCHOS telescope viewed from the inside of the enclosure. The opening of the enclosure faces South.*

From September 27 to October 1, 2004, the integrated telescope was presented and the first part of the training of the personnel of N.O.A. by the Zeiss specialists took place. On September 30 we got the first trial images through the science CCD of ARISTARCHOS. Among other objects, we observed the Saturn nebula, which is shown in the next figure. Despite the fact that the adjustment of the optics was still going on and the alignment was not complete, and given that the night was not photometric, this image gives a first impression of the abilities of ARISTARCHOS.

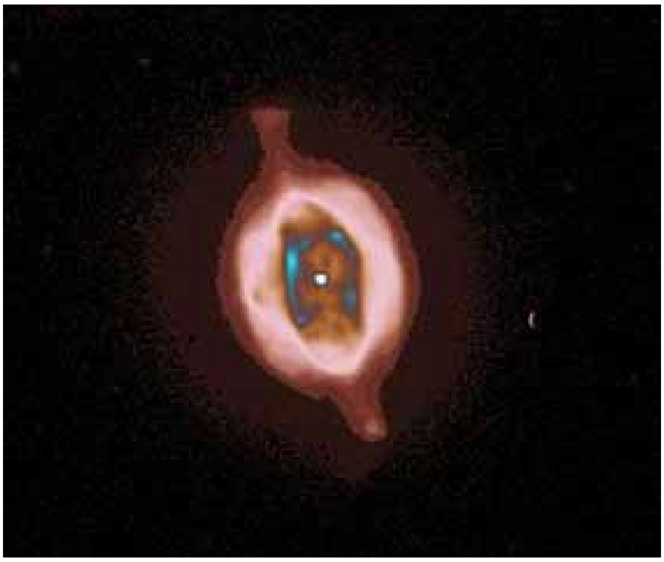


***Figure 2:** The Saturn nebula observed with the science CCD of the ARISTARCHOS telescope.*

With the final acceptance of the telescope and its availability for astronomical observations a major step forward of modern Hellenic science will be achieved. A great scientific project for our country, which started in 1998, is now approaching towards its conclusion. The ARISTARCHOS telescope utilises modern technology and its abilities will push forward Hellenic observational astronomy. At an altitude of 2340 m above sea level and under a very dark sky, one of the darkest spots in continental Europe, ARISTARCHOS will be able to explore the universe beyond half of its today observable radius.

Panajiotis Hantzios

IAA, NOA

TOP ASTRONOMY STORIES FOR 2004

According to the Physics News, the Bulletin of the American Institute of Physics, among the top physics stories for 2004, we found the three related to Astronomy:

- The detection of large galaxies located at a very early period in the history of the universe (http://www.aip.org/pnu/2004/split/668-1.html)
- New support for an accelerating cosmic expansion (http://www.aip.org/pnu/2004/split/675-1.html)
- The discovery of a planet-like object, Sedna, the most distant object observed in the solar system (http://www.aip.org/pnu/2004/split/677-1.html)

Retirement
John D. Hadjidemetriou

Professor John D. Hadjidemetriou has retired from the University of Thessaloniki at the 31st of August 2004.

He obtained his degree in Mathematics with Honours from the University of Thessaloniki (A.U.Th.). He received his PhD in 1965 from the Department of Astronomy, University of Manchester on the two-body problem with variable mass, under the supervision of the late Prof. Z. Kopal. He was elected Professor of Theoretical Mechanics at the Physics Department, University of Thessaloniki in 1970.

Professor Hadjidemetriou is a prominent teacher and researcher in the field of Dynamics in Greece and abroad. Many Physicists, Mathematicians and Astronomers in Greece benefited from his courses in Theoretical Mechanics, Theory of Relativity, Continuum Mechanics, Dynamical Systems and Chaos in A.U.Th. and from his teaching in many Summer schools or advanced Study Institutes on nonlinear dynamics. He is the author of one two-volume book in Theoretical Mechanics and one book in Continuum Mechanics.

Besides being a prominent teacher, Prof. Hadjidememtriou is also an eminent researcher in the field of Celestial Mechanics and Dynamical Systems. He is the author of many scientific papers and monographs and supervised 7 Doctor's Theses and many under- or post-graduate dissertations. He participated in a large number of conferences in Greece and abroad, in most of them as an invited main speaker.

He was the President (2000-03) or Vice-President (1997-2000) of the "*Celestial Mechanics and Dynamical Astronomy*" Commission of the IAU and elected member of the "*Celestial Mechanics Institute*" since 1992. He is Associate Editor of the international journal "*Celestial Mechanics and Dynamical Astronomy*" since 1993 and member of the editorial board of the international journal "*Astrophysics and Space Science*" (1965-90). He was the coordinator of the HCM Research Programme "*Order and Chaos in Conservative Dynamical Systems*" and scientific responsible for A.U.Th. in research programmes on "*Asteroids, comets and meteors*" (HCM) and "*Dynamical and physical evolution of meteoroids, asteroids and comets*" (Science). Finally, he was for many years responsible of the Erasmus Programme "*Mathematics and fundamental applications*" for the University of Thessaloniki.

He was the first to prove the existence of families of periodic orbits in the general three-body problem. He worked on the construction of symplectic maps for the efficient description of the dynamics of Hamiltonian systems, with important applications to the dynamics and the distribution of the main-belt asteroids and the Kuiper belt objects. Now he is actively working on the dynamics of the recently discovered extrasolar planetary systems. We are sure that the Greek Physists and Astronomers will benefit from his ideas and work for many years to come.

by Simos Ichtiaroglou
University of Thessaloniki

Women in Astronomy

One of the science fields in which women have made significant contributions is Astronomy. Still they are a minority compared to male astronomers, even in the most developed countries. In the following table we list data from the IAU, extracted from a recent article by Jocelyn Bell in Astronomy & Geophysics, December 2004. The table provides: the number of IAU members for every country, the percentage compared to the rest of the world and the percentage of women. Only countries with more than 100 members in IAU are included. Greece is not in a very bad position but still the average numbers for both Greece (13.33%) and the rest of the world (12.82%) are disappointing. It is noticeable that Argentina and Brazil (2 non-typical western societies) are doing considerably better than USA and EU.

IAU statistics on women in astronomy

National Member	No. of members	% of total	% of women
Argentina	106	1.17	34.91
France	633	6.96	25.91
Italy	443	4.87	20.77
Brazil	143	1.57	20.28
Ukraine	162	1.78	19.14
Spain	245	2.69	17.55
Russia	377	4.14	17.51
Belgium	110	1.21	13.64
Greece	**105**	**1.15**	**13.33**
Sweden	108	1.19	12.04
China	291	3.2	11.68
USA	2457	27.01	10.34
Poland	128	1.41	10.16
Australia	217	2.39	10.14
UK	582	6.4	10.14
Netherlands	178	1.96	8.99
Canada	197	2.17	8.63
Germany	492	5.41	6.50
India	224	2.46	5.80
Japan	504	5.54	3.97
Total Nat. members	**9027**	**100**	**12.82**

Workshop on "General Relativistic Plasma Physics"
Thessaloniki, 27/8-2/9/2004

A new research project, entitled *"Non-linear interaction of Gravitational Waves (GWs) with plasmas"*, has been funded recently at the Aristotle University of Thessaloniki (AUTH) by the Greek Ministry of Education in the frame of the *Pythagoras* program. The purpose of this project is the investigation of the complex phenomena arising in plasmas that meet general relativistic conditions, and of the influence that the presence of plasma and/or a magnetic field has on otherwise 'known' relativistic phenomena. Main topics of our research are the interaction of gravitational waves with plasmas, e.g. the generation of MHD or plasma waves by GWs, the back-reaction of the plasma waves onto the GWs, GW propagation in different types of curved space times, including the early Universe, and the conversion of GW energy into electromagnetic energy. The research group is led by Profs. L. Vlahos and D. Papadopoulos, and the group members are Drs H. Isliker, K. Kleidis, A. Kuirukidis and I. Sandberg.

In the frame of our activities, our group organized a topical workshop in Thessaloniki (27/8 – 2/9/2004), with partial financial support by the Pythagoras program. The main goals of this meeting were to review the current status of the extremely interdisciplinary problem of "general relativistic plasma physics" with a series of tutorials*, to provide an overview on open questions in the field, and to present latest results of research conducted by our group as well as by the invited participants.

The meeting started with a tutorial by Dr M. Marklund (University of Umeå) on covariant approaches to relativistic plasmas in astrophysics and cosmology. This talk established a solid ground for the formulation of a theory of electromagnetic fields and plasmas in curved spaces. Prof. K. Kokkotas (AUTH) presented two successive talks on GWs, their detection, and their potential astrophysical and cosmological sources. J. Moorgat (Nijmegen University) presented a model of MHD equations in the framework of General Relativity. Prof N. Stergioulas (AUTH) and Dr H. Dimmelmair (MPA- Garching, Munich) presented the current state of numerical simulations of 3D hydrodynamic and MHD models in the framework of general relativity, and discussed several applications, e.g. to magnetized stars. Dr A. Kuirukidis discussed a consistent model for the propagation of GWs through plasma in curved space-time, and Prof. D. Papadopoulos analyzed the interaction of spinning particles with GWs. A whole day was devoted to open cosmological problems with tutorial talks given by Prof. N. Spyrou (AUTH) on the conformal dynamical equivalence and cosmological consequences, Prof. Ch. Tsagas (Cambridge University and currently AUTH) on relativistic cosmology and perturbation theory, and on the superadiabatic amplification of primordial magnetic fields, Dr K. Kleidis on GW propagation in the frame of cosmological models, Prof. D. Papadopoulos on the magnetized Jeans instability, and Dr. E. Guendelman (Ben Gurion University, Israel) on the consequences of a dynamical volume element. The last day of the workshop was devoted to the nonlinear interaction of GWs with plasmas. A. Källberg (Umeå University) discussed the problem of nonlinear wave-wave interactions of GWs and MHD modes, Dr. H. Isliker presented a tutorial on the pseudo spectral method for solving non-linear partial differential equations, Dr. I. Sandberg showed numerical results on the excitation of MHD waves, non-linearly driven by GWs, and Prof L. Vlahos discussed the non-linear interaction of GWs with charged particles. The meeting closed with a reviewing summary and suggestions for the next steps by Prof. J. Kuijpers (Nijmegen University).

By Loukas Vlahos

Aristotle University of Thessaloniki

Review Article : Order and chaos in the asteroid belt

By Harry Varvoglis, Aristotle University of Thessaloniki

1. Order in the asteroid belt

Celestial Mechanics, the first branch of Astronomy where mathematical modelling managed to interpret and predict celestial phenomena, has a record of impressive achievements. In less than three hundred years, starting from Newton's law of gravitation and his three laws of dynamics, Celestial Mechanics managed finally to accurately describe, in practice, the trajectories of all planets and minor bodies of our solar system. The theory, behind all this, starts from the solution of the two-body problem and its particular properties.

A three-dimensional elliptic orbit of the two-body problem is uniquely defined by three quantities, which are related to the energy and angular momentum. These quantities are the three *elements* of the orbit a, e and i, where i is the *inclination* of the plane of the orbit with respect to a "reference" plane, a is the semi-major axis of the ellipse and e is the *eccentricity*. In what follows we consider the motion of massless test-particles (i.e. asteroids) relative to a massive central body (i.e. the Sun) of mass M. The orbital elements of an asteroid are related to the energy, E, and the angular momentum, h, of its orbit, through the relations

$$a = -\frac{GM}{2E} \qquad e = \sqrt{1 + \frac{2Eh^2}{G^2M^2}} \quad .$$

For elliptic motion, the orbital energy, E, has to be negative.

The two-body problem is only a simple approximation of a planet's motion around the Sun. A better approximation is the restricted three-body problem. In this model a massless particle (an asteroid) is moving in the gravitational field of two bodies, a central massive primary of mass M (the Sun) and a perturbing planet of mass m (say Jupiter). Moreover, the motion of the perturbing planet around the Sun is a Keplerian closed orbit (i.e. either a circle or an ellipse, whose elements are usually represented by primed symbols). The trajectory of the massless body is not anymore an ellipse, due to the perturbations induced by the planet. However, due to the small mass of the perturber relative to the Sun and for relatively large separation between the asteroid and the perturber, the trajectory can be described by means of the *osculating elements*, i.e. instantaneous values of the variables $a(t)$, $e(t)$ and $i(t)$, defined as the elements of an ellipse that is tangent to the real orbit at time t. The process is very easily implemented, since it reduces to the calculation of the elements of the orbit from the instantaneous values of the energy and the angular momentum (which, of course, are not anymore constants in the case of the three-body problem). From the work of Laplace and Lagrange we know that, in a linear theory and far from resonances, the osculating semi-major axis of an asteroid is constant and the osculating eccentricity is given by

$$e^2 = e_f^2 + e_P^2 + 2e_f e_P \cos(g_P t + \beta_P)$$

where e_f, e_P, g_P and β_P (the phase at t = 0) are constants. In particular g_P (usually called *proper frequency*) depends only on a and μ *(reduced mass)*, and e_f (usually called *forced eccentricity*) on a, μ, and e', while e_P is the constant amplitude of variation of the osculating eccentricity. In the full, non-linearized problem, e_P can be calculated through a more involved theory and it is called *proper eccentricity*. In a similar way one can define *proper semi-major axes*

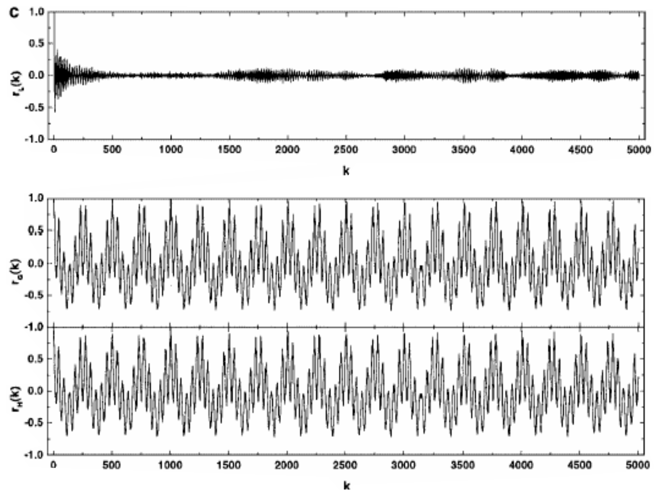


Figure 1. *The autocorrelation functions of the three Delaunay variables of a stable chaotic asteroid. The one corresponding to the semi-major axis (top panel) drops almost exponentially, an indication that the variations of the semi-major axis are chaotic. The autocorrelation functions of the other two actions, however, which correspond to the eccentricity and inclination, oscillate roughly between, +1 and -1, an indication that their variations are quasi-periodic, so that they cannot be modeled as diffusion in the corresponding action space.*

and *proper inclinations.* Proper elements are integrals of motion of the truncated, integrable problem and are, therefore, constants characterizing the orbit of an asteroid.

2. Chaos in the asteroid belt

Astronomers attempted to solve the restricted three-body problem for more than two centuries, without any success. At the end of nineteenth century

Poincaré showed that this problem is non-integrable, so that a general solution does not exist. Moreover Poincaré showed that in some regions of phase space the trajectories of non-integrable dynamical systems are very sensitive to initial conditions, a property that today is characterized as *deterministic chaos* and is measured by the *Lyapunov time*, the time needed for a trajectory to "forget" its initial conditions. Small Lyapunov times correspond to strong chaos. One may calculate a Lyapunov time for each degree of freedom but, usually, only the smallest one is calculated, the Minimal Lyapunov Time, which is usually called, simply, Lyapunov time.

After the appearance of computers it was understood, through numerical integration of orbits, that the simplest model used in Celestial Mechanics, the planar restricted three-body problem, possesses *non-ignorable* chaotic regions in phase space. In this way it became widely accepted that chaos is an important phenomenon in the solar system. Therefore Newton's idea of a clockwork universe, which, once started to move, would continue moving in the same way "ad perpetuum", suddenly was proven to be wrong. The bodies of the solar system, especially the minor ones such as asteroids, may follow trajectories that change within a Lyapunov time, so that "collisions" (either true or just close encounters) and ejections play an important role as sinks (both) and sources (the former) of bodies, even in the present era. As a result, the question now is not anymore whether chaos affects the dynamics of planetary systems, but on which time-scales it does so and on whether it is the rule or the exception. Recent calculations put the percentage of main belt asteroids on chaotic orbits up to 30% .

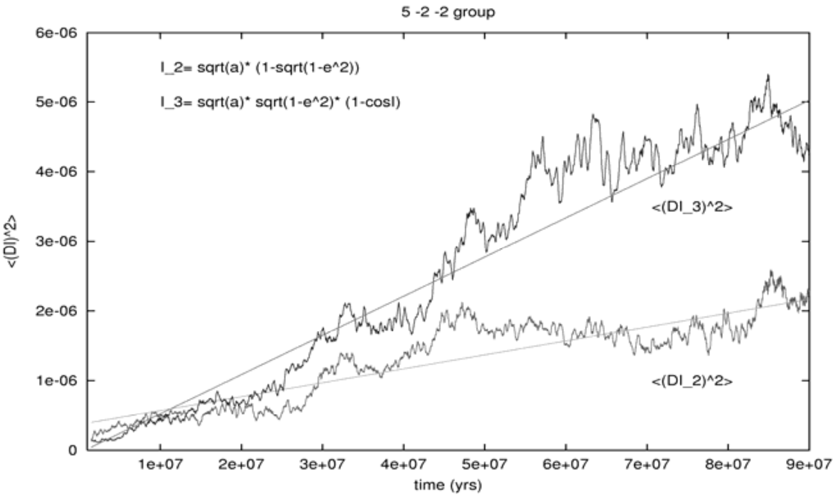


Figure 2. *Some members of the Veritas family are in a (5 -2 -2) resonance with Jupiter and Saturn. The evolution of the variance of the I_2 and I_3 actions, as a function of time, for the chaotic members of this group is linear in time. The action I_2 is related to the eccentricity and the action I_3 is related to the inclination. Note the different value of the diffusion coefficient in the two actions.*

In chaotic dynamical systems the evolution of the generalized co-ordinates and momenta is, in general, macroscopically similar to a random walk. Therefore, one might use methods of statistical mechanics (e.g. the Fokker-Planck equation) in order to describe the evolution of a set of initial conditions as a diffusion process in the proper elements space *a*, *e*, *i*. In particular it is easy to see that *e* increases on the average. If we consider the chaotic motion as a random walk in eccentricity space, there is a reflecting wall at *e* = 0, since, by definition, *e* is a non-negative quantity. The net result is that asteroids in fully chaotic trajectories follow more and more elongated orbits, until they hit a planet and are removed from the distribution.

3. Applications to specific astronomical problems

The statistical approach to problems that involve diffusive motion of asteroids has found already several applications. Our group has contributed to the understanding of some of them.

3.1 Lyapunov time vs. escape time from the asteroid belt

The first group which attempted a statistical description of chaotic motions in the asteroid belt was the one by Lecar. These authors performed numerical experiments, by integrating the equations of motion for a large number of asteroids and they calculated the Lyapunov time of each trajectory as well as a "characteristic" time, which was meant to describe the time needed for the eccentricity of an asteroid to reach a planet crossing value, after which it would soon be ejected from the main asteroid belt due to a close encounter. They arrived at a very surprising conclusion: the plot of characteristic times vs. Lyapunov times showed a linear trend in a log-log plot, similar to the one shown in Fig. 4 of the present article. They interpreted this result as a "universal law" in the asteroid belt. As it turned out, the trend is real but the correlation coefficient is low, so that it cannot be considered as a *law*. Lecar and his co-workers found a *strong* correlation, only because, in order to speed up numerical integrations, they assigned to Jupiter a mass ten times larger than its real one. But in this way they changed the dynamics of the system since, for such a large mass, all ordered trajectories disappear and the outer part of the asteroid belt becomes a simply connected chaotic region. However this unexpected result triggered a number of papers by other authors, who tried to understand and interpret it.

Our group introduced to this problem a purely statistical approach. We assumed that the asteroid motion is a random walk in eccentricity space and we wrote down a modified Fokker-Planck equation. Then we considered the limiting case of strong perturbation, when the surviving regions of stability are of negligible measure. By assuming that the diffusion coefficient in this case depends on the value of the Lyapunov time and is independent of the eccentricity, we solved the equation analytically and showed that a relation similar to the one found by the Lecar group is naturally recovered.

3.2 Stable chaos

In conservative systems with more than two degrees of freedom, some of the degrees might be strongly chaotic, so that the Minimum Lyapunov Time has a small value, while others might be so mildly chaotic, as to appear ordered on physically important time-scales. In this way the particles diffuse, in the space of the strongly chaotic degrees, on a much shorter time-scale than in the space of the mildly chaotic ones. A typical example is the case of *stable chaos* in the solar system. In a stable chaotic trajectory, the autocorrelation function of one action (corresponding to the semi-major axis) decays on a time scale of the order of the Lyapunov time. However, the autocorrelation functions of the other two actions (corresponding to the eccentricity and the inclination) vary quasi-periodically for thousands of Lyapunov times (Fig. 1). Therefore correlations in the eccentricity do not decay fast and the process cannot be considered as diffusion in eccentricity and/or inclination space (although it might be considered as diffusion in semi-major axis space). We interpret this situation as a mixed chaotic-sticky behavior. The trajectory is chaotic, with respect to the semi-major axis, but sticky with respect to eccentricity and inclination.

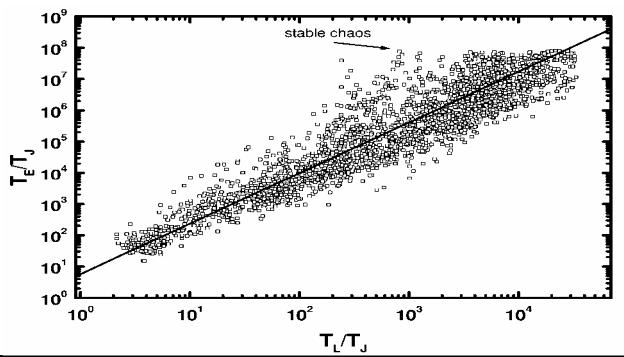


Figure 3. *The relation between the Lyapunov time of Trojans (T_L) and their escape time through a collision with Jupiter (T_E), measured in Jupiter's periods (T_J). Several cases of stable chaos are noted.*

3.3 Chronology of the Veritas family

Asteroid families are groups of asteroids, whose proper elements are nearly identical, and they are named after the larger body in the group. It is assumed that families were created in the past by collisions between large parent bodies. It was already known that several members of the Veritas family, including the largest body in the family, asteroid (490) Veritas itself, are located inside a chaotic zone of the asteroid belt, characterized by Lyapunov times of the order of 10,000 yrs. Chaotic diffusion brings these bodies outside the family boundaries on a 100 Myrs time-scale, which can be interpreted as an upper bound to the age of the family. Our group confirmed that the motion of the chaotic family members is indeed diffusive, by showing that the evolution of the variance of the eccentricity and inclination obey Fick's law and, from the slope of the curve $\sigma^2(t) = D \cdot t$, estimated the diffusion coefficient (Fig. 2). Then, by assuming that the initial probability density function of the family members was a δ-function, we compared the analytical solution of the Fokker-Planck equation to the observed distribution of the actual chaotic members of the family. From this we estimated that the age of the family is approximately 9 Myrs, a value that agrees nicely with the result found recently by Nesvorny *et al.*, who integrated backwards the trajectories of the ordered family members until they clustered in the past.

3.4 Chaotic diffusion of Jupiter Trojans

Jupiter Trojans are asteroids librating about Jupiter's stable Lagrange points L_4 and L_5, which lie on Jupiter's orbit 60° ahead and 60° behind Jupiter. We now know that an important fraction of Jupiter Trojans follow chaotic orbits. Many types of secondary resonances exist in the region of the Trojans, resulting in a slow chaotic motion, which resembles to a diffusive evolution of the width of libration and results in a slow depletion of the L_4 and L_5 regions. However, the question whether this slow depletion is the result of chaotic diffusion or of a non-conservative phenomenon (e.g. collisions or radiation forces, such as the Yarkovsky effect) remained open for some years.

Our group derived the distribution of regular and chaotic bodies near the L_4 and L_5 regions as a function of proper elements. We also defined the "effective stability region", in which a Trojan has an escape time greater than the age of the solar system. For objects escaping in less than 1 Gyr, we showed that a power-law trend exists, relating the Lyapunov and the escape time scales (Fig. 3). Finally, using observational data, we estimated the diameters of the Trojans and derived the distributions of diameter for (i) the population of ordered and (ii) the population of chaotic Trojans. The two distributions were found to be nearly identical, which shows that the transport of Trojans from the outskirts of the effective stability region towards the chaotic domain is a size-independent process, i.e. chaotic diffusion instead of radiation forces or collisions.

3.5 The steady state population inside the 7:3 Kirkwood gap

A population of 23 asteroids is currently observed in a very unstable region of the main belt, the 7/3 Kirkwood gap. The small size of these bodies as well as the computation of their dynamical escape lifetimes ($3 < T_D < 172$ Myr) shows that they cannot be on their primordial orbits, but were recently injected in the resonance. We considered as a clue to the above problem the distribution of inclinations of the resonant asteroids, which appears to be bimodal, the two peaks being close to 2^o and 10^o. The solution we proposed is that the resonant population, which is continuously decaying due to the dynamical escape of asteroids, is constantly being replenished by the slow leakage of asteroids from the adjacent Koronis (with proper inclination $i \approx 2^o$) and Eos (with proper inclination $i \approx 10^o$) families, due to the drift of the asteroid's semi-major axes, caused by the *Yarkovsky effect*. In particular, from the dynamical lifetimes we calculated on the one hand the outward flux of asteroids, due to chaotic diffusion, and on the other the inward flux, due to the Yarkovsky drift. By equating the two fluxes we calculated the number density of the two families needed to sustain the currently observed population in a steady state. The observed distribution functions of both families members vs. semi-major axis are in very good agreement with our calculations (Fig. 4). This was one of the first results that revealed the importance of the Yarkovsky effect in the asteroid belt.

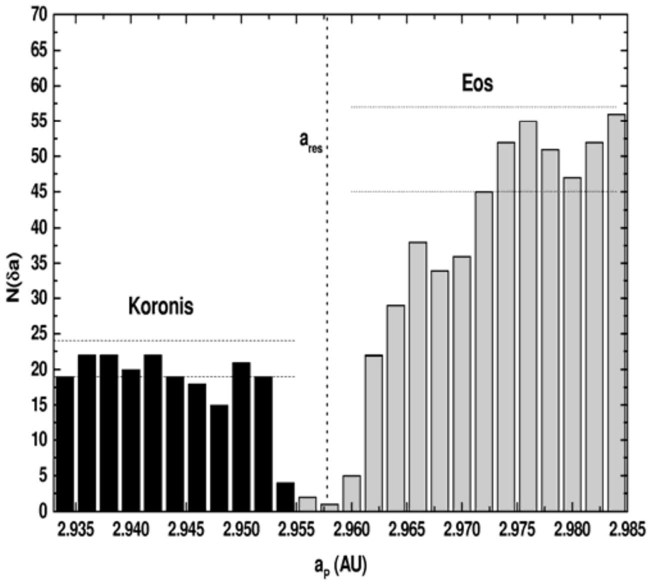


Figure 4. *Histogram of the number of observed members of the Koronis and Eos families, binned to 0.002 AU. The Koronis family has ~ 20 members per bin, while the Eos family has ~ 50 members per bin. The horizontal lines mark the values, needed for the Yarkovsky flux to keep the observed bimodal resonant population in a steady state, for two extreme configurations: either spin axes of the asteroids are aligned perpendicular to the ecliptic (lower line), or they are randomly oriented (upper line).*

4. Discussion and conclusions

Proper elements theory is considered as the ultimate tool for studying the long time evolution of the Solar System, in general, and the asteroid belt, in particular. It is interesting to note that proper elements turn out to be of use not only in the case of asteroids on ordered motion, when the corresponding theory is valid, but even in some cases of mildly chaotic trajectories. However the theory has its limitations and becomes meaningless for asteroids with Lyapunov times less than 10^4 years. For these cases it might be more appropriate to change the way of approach and, instead of trying to make accurate predictions for the motion of individual bodies, it could be more instructive to seek the statistical evolution of a whole ensemble. According to the theory of Laplace-Lagrange, the semi-major axis does not show important secular changes, so that we focus our attention to the evolution of eccentricity and inclination. If the process in the corresponding actions can be considered as *diffusion*, the appropriate mathematical tool that can help us in this task is the Fokker-Planck equation, which in the case of conservative systems contains only one parameter, the *diffusion coefficient*. Therefore all information that can be drawn from the point of view of Statistical Physics depends only on the knowledge of the diffusion coefficient and the initial distribution of the ensemble of asteroids.

Despite the fact that our knowledge on the dynamics of the diffusion mechanism and the functional form of the diffusion coefficient is presently limited, the diffusive approach and its tools turned out to be of use in attacking several real problems. In the present article we presented five such applications. In the first we have recovered theoretically an observed correlation between the escape and Lyapunov times of asteroids in the main belt. In the second we have understood the phenomenon of stable chaos as stickyness in two degrees of freedom in a three-degrees of freedom dynamical system. In the third, the age of the Veritas family is estimated by assuming that its members are diffusing with a constant diffusion coefficient, which was calculated numerically. In the fourth it is concluded that the evolution of Jupiter Trojans is diffusive, on two indications: first that their Lyapunov times have a positive correlation to their escape times, a fact that characterizes diffusion, and second that the distributions of both ordered and chaotic Trojans with respect to their diameters are effectively identical, a fact that precludes the importance of non-gravitational forces. Finally in the fifth we have interpreted the existence of the unstable population in the 7:3 Kirkwood gap as a steady-state equilibrium between the outward flux, due to the escape of asteroids from the region, and the inward flux, due to the Yarkovsky effect. It is hoped that in the near future the theoretical understanding of diffusion in the asteroid belt will enable the tackling of more sophisticated problems.

Acknowledgments

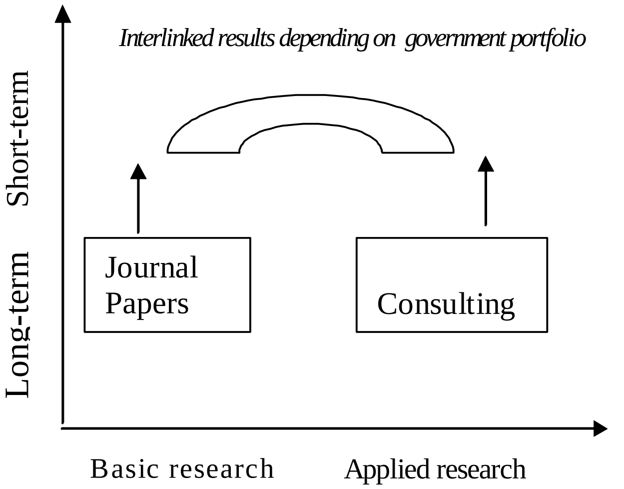
Part of this article is based on work that has been done in collaboration with (alphabetically) Profs. R. Dvorak and J. Hadjidemetriou and Drs. A. Anastasiadis, A. Morbidelli and K. Tsiganis.

Greece's World-wide Performance in "Astronomy and Astrophysics"

By Emilios Harlaftis

National Observatory of Athens

The debate in research policy circles for supporting and at which ratio basic against applied research is particularly fervid, particularly since the application of the fifth framework programme in R&T in the EU. An interesting example is shown below regarding the timescale at which the basic research results are linked to applied research (and thus industry). This timescale is dependent on the government's coordination and policies. The figure was presented by Prof. A. Penzias (Venture capitalist; 1978 Nobel prize for discovering the microwave background) in order to articulate how wrong it is to separate basic research from applied research, especially in developing countries (the 18th Physics Nobel Laureates Meeting at Lindau, 27 June-1 July 2004).



Among basic research, Astronomy is perhaps the most representative science field. "The object of Astronomy is to conduct forefront research, thereby expanding humanity's knowledge of the space environment and the cosmos. Astronomers in Greece share this purpose and aspire to partake in cutting-edge research at the highest levels in a milieu where opportunities for participation are possible in both the national and global arena. Such participation accrues benefits to science, advances technology and education, and elevates the aspirations of the entire nation". Having a vision provided by the International Advisory GNCA of the GSRT [3], the next question is how the community relates to the government for the implementation of its needs, especially with regard to instrumentation projects which can provide the missing link to applied research. One fundamental issue is that public policy makers do not ask the right questions at the astronomical community to support potential technology "spin-offs". Also, the astronomers themselves, may not be efficient, sometimes, in promoting their aims and needs. In particular, the advanced technology, informatics and education benefits which can result from modern PhD programs in astrophysics may have not, sufficiently, been demonstrated to the Greek funding agencies as in UK, Spain, Denmark and Netherlands.

For example, it is not by coincidence that astronomy has produced the most sophisticated bibliographic system, the NASA Astrophysics Data System (ADS). How this is changing our attitude towards the information society is evident from its use by the scientific community. The ADS users, through internet access, read ~10 times the journal papers read in all

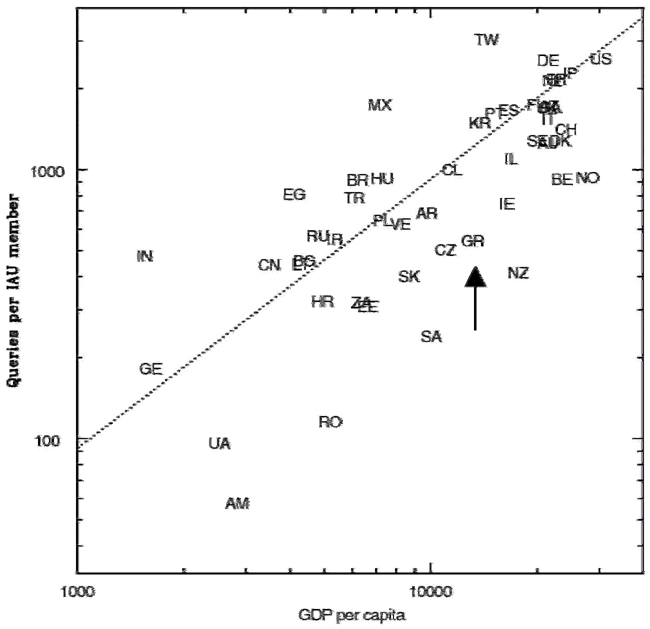


***Figure 1**: the number of ADS queries per IAU member as a function of GDP per capita. The dotted line indicates that research productivity is not independent of location. Greece falls beneath the dotted line implying that the number of ADS queries per IAU member should have been higher for the Greek GDP per capita.*

traditional libraries combined. A recent analysis by the Head of ADS [2] shows the various parameters that can be extracted from the ADS in order to provide quantitative research performance for nations, regions, Institutes, researchers etc. Here, we present three figures relevant for Greece [2].

Assuming that astronomy is representative of basic research, Kurtz et al. [2] extend this relation to:

$$BasicResearch \sim Scientists * (GDP/Population)$$

In other words the amount of basic research pursued in Greece is proportional to the number of scientists times the per capita GDP.

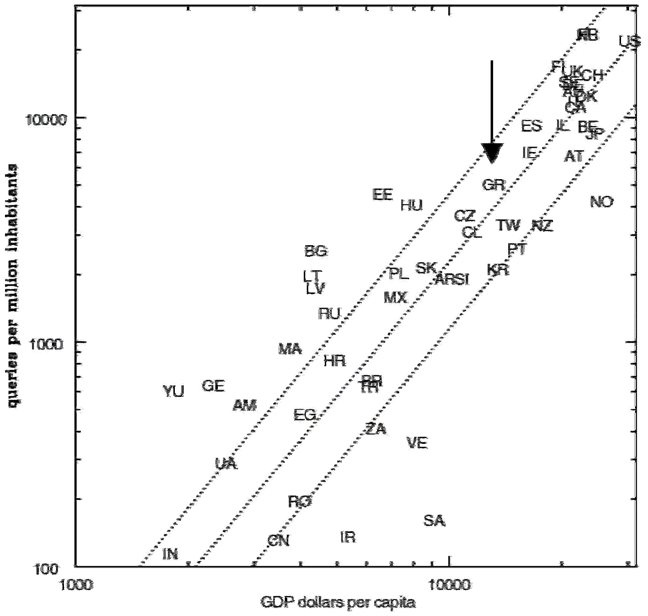


Figure 2: The IAU membership is proportional to GDP. Greece falls below the central dotted line by a factor of more than three which can be interpreted as a cultural difference with the other nations.

Nevertheless, the domain of astronomy and astrophysics is the fifth most visible Greek science contributing at least 3.5% of the national research papers and 0.90% of the world-wide astronomy output [4]. The latter is also consistent with a treatise presented by Harlaftis [1] (also 0.9%) and it compares with the 0.39% world GDP and 0.17% world population for Greece (http://www.phrasebase.com/countries/). Such indicators should call in government action aiming to provide targeted funding for dormant areas in forefront research and instrumentation activities, as advised by international peer-review panels (vertical action for scientific domains). It is notable that peer-review for the Institutes supervised by GSRT has been undertaken twice in the last 10 years and it is about to start soon for the teaching-oriented Universities (horizontal action for Institutes).

Such exercises are of relevance in order to provide the context against which we wish to build upon and take advantage of Greece's membership of *ESA* (2004) and *OPTICON* (European optical/IR astronomy infrastructure network, 2004) which should rationally lead into larger state investment in advanced technologies through infrastructures, instrument laboratories and development of the local human capital, under frequent international peer-review, and in cooperation with the *European Southern Observatory*, the leading international organization in astronomy.

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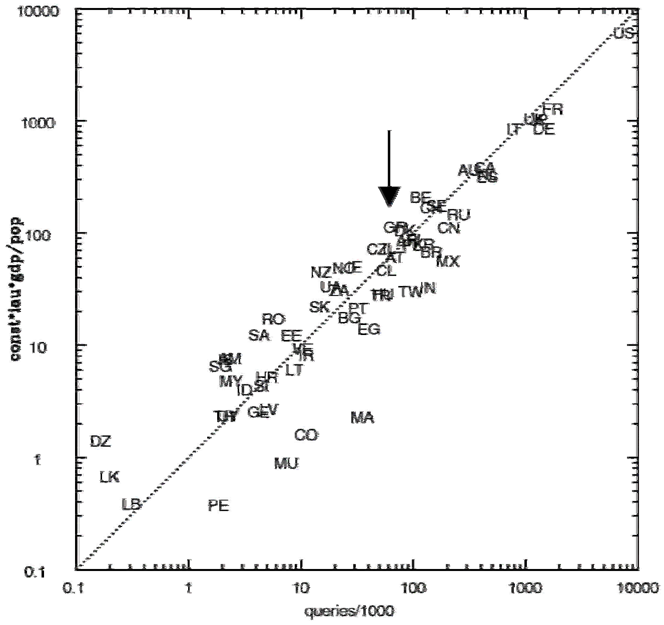

Figure 3: The ADS use is proportional to the number of astronomers times the GDP per capita (dotted line) representing the same average linear relation at the left panel after some rearrangement. Notably, Greece is well behind UK, Germany, Italy, France and Spain.

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SPACE NEWS

SPITZER: The Spitzer Science Archive is now available online from the Spitzer home page. The archive includes data from the 110-hour "first look" survey on the mid-infrared sky, and information from the Spitzer Legacy Science program **(http://www.spitzer.caltech.edu).**

SWARM: ESA's Earth Observation Programme Board has given the go-ahead for an Earth Explorer Opportunity Mission called SWARM—a constellation of three satellites that will study the Earth's magnetic field. The objective is to provide the best ever survey of the geomagnetic field and its temporal evolution, in order to gain new insights into the Earth system by improving our understanding of the Earth's interior and climate. The mission will launch in 2009 **(http://www.esa.int/export/esaLP/swarm.html).**

GANYMEDE: Recent analysis of the radio transmissions sent back by Galileo as it flew past Ganymede indicates that the giant moon might contain "lumps" of rock within its thick icy crust.

Review Article: Star Formation and Infrared Emission in Galaxies

By Nikolaos D. Kylafis & Angelos Misiorotis,
Department of Physics, University of Crete

The relationship between star formation and infrared emission in galaxies will be investigated. If galaxies were simple objects and young stars were completely covered with dust, then all the absorbed light of the young stars would be re-emitted in the infrared and from the infrared emission of galaxies we would infer the star formation rate (SFR) in them accurately. To show the complexities involved in real galaxies, we will use as a case study the late-type spiral galaxies. We will show that the heating of the dust is done mainly by the UV radiation of the young stars and therefore the infrared emission reveals the SFR in them. With a realistic model and its application to a number of galaxies, tight correlations are derived between SFR and total far infrared luminosity on one hand, and dust mass and 850 micron flux on the other. Other diagnostics of the SFR are examined and it is shown that there is consistency among them. Thus, the SFR for galaxies of all Hubble types has been determined as well as for interacting starburst galaxies. Combining different methods, the star-formation history of the universe has been determined and will be shown. Finally, some early results from the Spitzer Space Telescope will be presented.

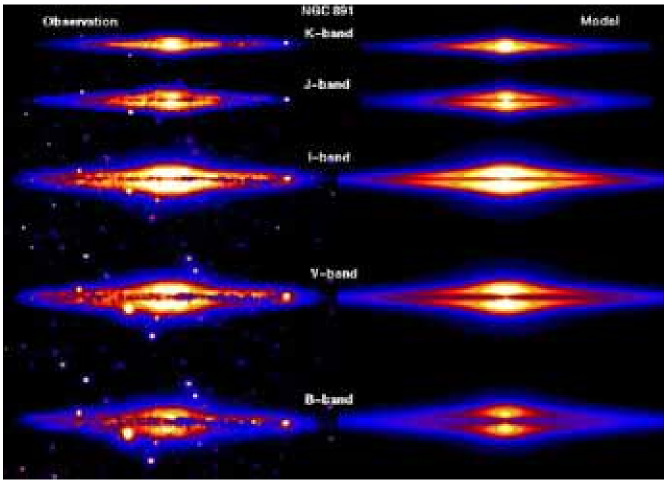

Figure1: Images of NGC 891 in the K, J, I, V, and B bands and the corresponding models.

1. Introduction

We will start by asking the naive and rhetoric question of why should star formation and infrared emission in galaxies be connected.

If galaxies were simple objects, consisting of young stars surrounded by optically thick dust, then practically all the luminosity of the young stars would be absorbed by the dust and it would be re-emitted in the infrared (IR) part of the spectrum. Then, observation of the IR luminosity of a galaxy would give us, with the use of an initial mass function, the star formation rate (SFR) in the galaxy.

However, real galaxies are more complicated objects for the following reasons: 1) They consist mainly of old stars, which may also contribute to the heating of the dust. 2) The dust is distributed throughout a galaxy and not around its stars. 3) The optical

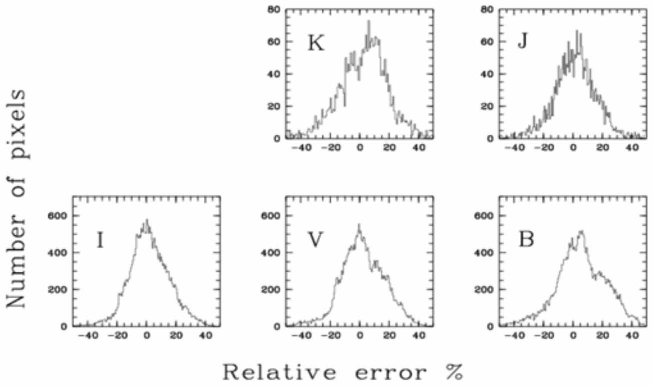

Figure2: Histograms of the relative errors between the pixels of the K, J, I, V, and B band observations and the corresponding models.

depth of the dust in a galaxy varies significantly with position in the galaxy and direction. Therefore, detailed modeling of the stars (young and old) and the dust in a galaxy is needed before trustworthy conclusions are drawn.

In what follows, we will treat late-type spiral galaxies as a case study. Then we will extend our discussion to all types of galaxies.

2. Model for late-type spiral galaxies

2.1. *Modeling of the optical light*

A successful model for late-type spiral galaxies has been applied to a number of galaxies by Xilouris et al. [35]. This model includes the old stellar population in the form of an exponential (both in radius and height) disk and a de Vaucouleurs [12] spheroid.

The dust is distributed in another exponential disk (with scales different than those of the stars). Comparison of model images with optical and near infrared (NIR) images of galaxies reveals the total amount of dust (warm and cold) in them and its distribution. Figure 1 shows NGC891 in five bands and the corresponding model images (Xilouris et al. [36]). The agreement between the model and the observations is very good. This is seen more clearly in Figure 2, where the residuals between the model and the observations are shown (Xilouris et al. [36]). The main conclusions of Xilouris et al. [35] are:

1. The scale height of the dust is about half that of the stars.
2. The radial scale length of the dust is about 1.4 times that of the stars. Furthermore, the dust extends beyond the optical disk.
3. The average gas-to-dust ratio of seven spiral galaxies is about 400, i.e. comparable to that of our Galaxy.
4. The extinction coefficient in the optical and NIR parts of the spectrum is the same as in our Galaxy, indicating common dust properties among spiral galaxies.
5. The central, face-on optical depth in the B-band of all seven galaxies is less than one. This means that, *if* all the dust has been accounted for in these galaxies, then late-type spiral galaxies are transparent.

Similar conclusions have been reached by Alton et al. [2] and Davies et al. [11]. The effects of spiral structure have been shown to be negligible (Misiriotis et al. [28]) and similarly for the effects of clumpiness in the dust (Misiriotis and Bianchi [27]).

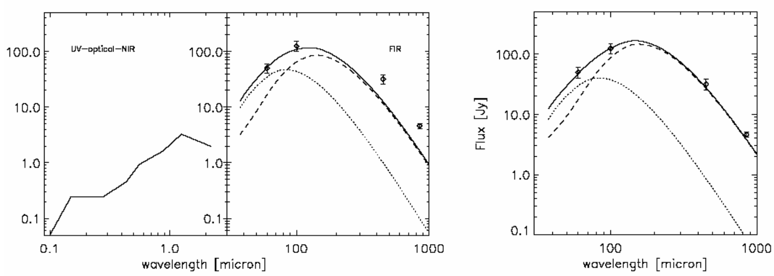

***Figure 3:** One- and two-dust-disk models of NGC 891.*

2.2 *Modeling of the infrared emission*

In order to model the IR emission of late-type spiral galaxies, one has to take into account the heating of the dust not only by the old stars but also by the young ones. This was done by Popescu et al. [33] for NGC 891 and by Misiriotis et al. [30] for four more galaxies. The model utilizes the dust distribution derived from the optical images and assumes that the young stars (and therefore the UV emission) are distributed in an exponential disk with a small scale height (90 pc) and scale length equal to the B-band scale length of the old stellar population. Part of the UV luminosity is absorbed by local sources (HII complexes) and the rest is diffuse. The far infrared (FIR) emissivity of the dust was taken to be the same as the one thought appropriate for our Galaxy (Laor & Draine [26]).

It was found that model fluxes in the submillimeter (submm) part of the spectrum are significantly lower than the observed ones (Fig. 3, left). In order to account for the "missing" submm flux, Popescu et al. [33] proposed that there is a second dust disk, not visible in the optical images, with scale height 90 pc (equal to that of the young stars). The mass in the second dust disk is about the same as that of the first. The model accounts (Fig. 3, right) not only for the spectral energy distribution (SED) of NGC 891 in the FIR/submm regime (Popescu et al. [33]), but also for its observed surface brightness at 170 and 200 m (Popescu et al. [34]). Furthermore, the model showed that the heating of the dust is done mainly by the UV. Thus, the star formation rate in NGC 891 is directly connected to its infrared emission.

It is, however, possible that the FIR/submm dust emissivity value used for our Galaxy (e.g. Draine & Lee [14]) has been underestimated. Alton et al. [3], using a simple but reliable model, studied the edge-on galaxies NGC 891, NGC 4013, and NGC 5907 and concluded that the emissivity at 850 m is about four times the widely adopted value of Draine & Lee [14]. A detailed model by Dasyra et al. [10] arrived at the same conclusion.

At the moment, the above degeneracy (i.e., more dust or higher emissivity) is not lifted, but the higher emissivity seems to be a real possibility (Dasyra et al. [10]).

3. Correlation between star formation and infrared emission

As we saw above, in order for one to fit the SED of a late-type spiral galaxy, a SFR must be assumed. The question then is: Can a correlation be found between SFR and infrared emission for a sample of late-type spiral galaxies? The answer is yes and it was given by Misiriotis et al. [29]. They studied 62 bright IRAS galaxies from the SCUBA Local Universe Galaxy Survey of Dunne et al. [15]. Figure 4 shows the derived dust mass of the galaxies as a function of their 850 μm luminosity. The correlation is linear and quite impressive. This is not surprising, because most of the dust in these galaxies (as in the galaxies studied by Xilouris et al. 1999) is cold (~15 K). In Figure 5, the derived SFR is shown as a function of the 100 μm luminosity. Since the peak of the SED of these galaxies is near 100 μm, it is again not surprising that the correlation is linear and quite tight. In Figure 6, the sought after correlation between SFR and IR luminosity is shown. The solid line is a linear fit to the data,

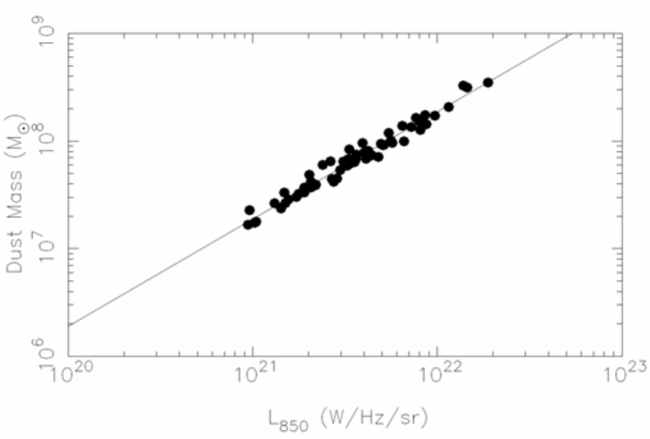

***Figure 4:** Dust mass as a function of luminosity at 850 μm. The solid line shows the best linear fit (in log-log space).*

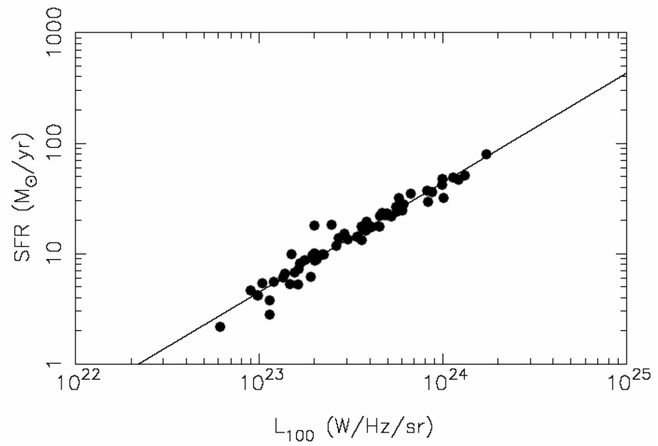

Figure 5: Star formation rate plotted as a function of L_{100} . The solid line is the best linear fit (in log-log space).

while the dashed one is the correlation of Kennicutt [23] (see also Buat & Xu [8]). The dot-dashed line shows the Kennicutt correlation if one assumes that the UV to IR transformation efficiency is not 100% (as in starbursts) but 50%.

4. Other star formation diagnostics

Several other SFR diagnostics have been used over the years and the question is how well they agree among themselves. The answer now is quite well, though this was not the case a few years ago.

Kewley et al. [24,25] showed that the SFR derived from the IR luminosity and that derived from Hα (properly corrected for extinction) are in excellent agreement *for all types of galaxies* (from elliptical, to spiral, to peculiar) and *for SFR ranging over four orders of magnitude*. The reader is also referred to the work of Buat et al. [7], Hirashita et al. [20], Panuzzo et al. [31], and Flores et al. [16].

The forbidden lines of [OII] have also been used as a measure of SFR. Kewley et al. [25] showed that the SFR derived from [OII] and that derived from Hα are in excellent agreement for all types of galaxies and for four orders of magnitude of the SFR.

Not surprisingly, the SFR determined from UV observations is in excellent agreement with the SFR determined from the IR (Iglesias-Páramo et al. [22]). On the other hand, what is somewhat surprising is the fact that the 1.4 GHz luminosity is a good indicator of the SFR. For an explanation of this, the reader is referred to Bressan et al. [6], but the explanation is not widely accepted (Bell [5]; Pierini et al. [32]). Afonso et al. ([1]) showed that the SFR determined from the 1.4 GHz luminosity is in good agreement with the SFR determined from Hα or [OII].

It is remarkable that even for interacting starburst galaxies there is a good correlation between the SFR derived from the Hα flux and the SFR derived from the FIR continuum (Dopita et al. [13]).

Last but not least, we want to mention the work of Förster Schreiber et al. [17], who used a sample of galaxies containing a) quiescent spiral galaxies, b) spiral galaxies with active circumnuclear regions, c) starburst galaxies, d) LIRGs, and e) ULIRGs and showed that the monochromatic 15 μm continuum and the 5 - 8.5*μm* emission constitute excellent indicators of SFR.

We believe that the above are more than convincing that the determination of the SFR in galaxies is a mature subject. Significant progress has also been made in the determination of the SFR history. The most recent work in this subject is that of Heavens et al. [18], who did an analysis of the 'fossil record' of the current stellar populations of 96,545 nearby galaxies, from which they obtained a complete star-formation history. They found that the peak of star formation was at about five billion years ago, i.e. more recently than other studies had found. They also found that the bigger the stellar mass of the galaxy, the earlier the stars were formed, which indicates that high- and low-mass galaxies have very different histories.

5. Instead of a summary

Instead of a summary, we want to mention just three of the recently reported very exciting results from the Spitzer Space Telescope.

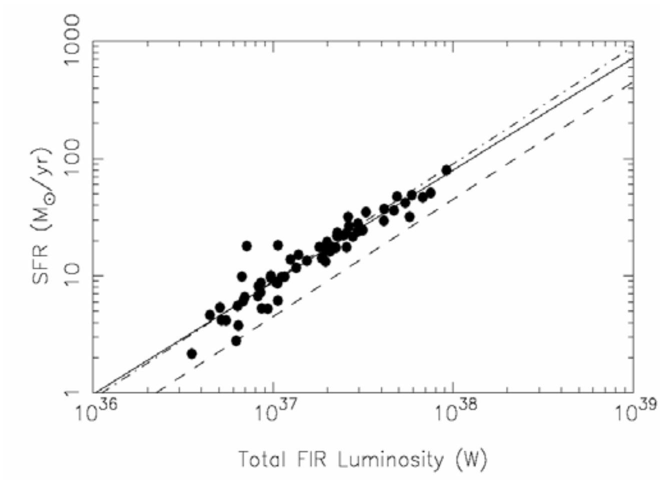

Figure 6: Star formation rate as a function of total FIR luminosity. The solid line is the best linear fit (in log-log space). The dashed line is drawn according to the SFR-L_{FIR} relation of Kennicutt [23] for starburst galaxies. The dash-dotted line is Kennicut's relation if one 50% rather than 100% transformation efficiency of UV into FIR.

Appleton et al. [4] reported that the FIR - radio correlation is valid to at least z=1 and similarly for the mid-infrared - radio correlation.

Higdon et al. [19] (see also Charmandaris et al. [9]) reported that the redshift of high-z, faint galaxies can be determined from the 14 - 38*μm* spectrum! This opens up tremendous possibilities for the determination of *z* of faint galaxies.

Houck et al. [21] reported that the blue compact dwarf galaxy SBS 0335-052, which has very low metallicity ($Z \sim Z_\odot/41$) has a featureless mid-infrared spectrum with a peak at ~28*μm*! Taken at face value, this means that there is no cold dust in this galaxy.

The reader is referred to the Special Issue of ApJS (Volume 154) for additional exciting results from Spitzer.

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Book Reviews

I.A. DAGLIS (ed.), Space Storms and Space Weather Hazards, Kluwer Academic Publishers, 2001, 482 pp., ISBN 1-4020-0030-8, (170 euro).

Solar-terrestrial physics concerns the study of the ways in which events on the Sun influence the near-Earth space environment. This field of scientific endeavor is now popularly termed "space weather". Particularly important are disturbances of the near-Earth space environment which affect the performance of a "high tech" system - on the ground or in space. Forecasting space weather conditions is thus a "hot topic" nowadays.

This excellent book contains 19 Chapters developed from tutorial lectures delivered at a NATO Advanced Study Institute held in Crete during June 2000 on "Space storms and space weather hazards". It is an impressive collection of papers which: a) provides a systematic overview and rigorous introduction to the physics of space storms, b) reviews recent spacecraft measurements that have provided new insight into the dynamics and effects of space storms, c) reviews space weather hazards associated with space storms and pertinent to the operation of technological systems, and d) discusses and assesses methods of space weather forecasting, as well as initiatives towards an efficient development of space climatology.

First, the Editor presents a well balanced overview Chapter covering both the phenomena observed and the fundamental physical processes involved. Y. Kamide then focuses on geomagnetic storms. J. Lemaire reviews the radiation belts discovered independently by J.A. Van Allen and S. Vernov. B.T. Tsurutani summarizes evidence for the interplanetary causes of substorms and magnetic storms, and N.F.Ness considers the important role of the interplanetary magnetic field, especially is direction, in "magnetic reconnection". J. Chen goes further, considering what solar wind structures are especially "geoeffective". P.J. Cargill goes into more detail on coronal mass ejection. B. Klecker covers plasma and energetic charged particle measurements. E.Friis-Christensen changes tack, covering possible effects on the Earth’s climate associated with solar activity. The roles of cosmic rays their properties, and the properties of other energetic charged particles as a radiation hazard to astronauts are explained by M.I. Panasyuk. D.N. Baker introduces anomalies of satellite/spacecraft behaviour due to such radiation, and L.J. Lanzerotti reviews space weather effects on communications. The impacts of space weather phenomena on electrical power (grid) systems are dealt with by J.G.Kappenman. Numerical modeling methods and results using MHD are brought in by M. Scholer, with K. Papadopoulos and also K. Tsinganos giving more details. J.A. Joselyn adopts a practical user’s perspective on state of the art space weather services and forecasting. The US Air Force viewpoint is put by G.P. Ginet, with E.J. Daly rounding the book off with ESA’s perspective.

XI-NEB on Lesvos

June 2-5, 2004

The series of meetings of the Greek relativity community, named NEB (Recent Developments in Gravity), were initiated by the late Vasilis Xanthopoulos in 1984. Since then, every two years Greek relativists working in Greece or abroad meet to present their research work and discuss recent developments in the field.

The 11th NEB conference was held during the week of June 2-5, 2004 in the Department of Marine Sciences of the University of the Aegean, at the beautiful new premises of this university located outside the town of Mytilene on the island of Lesvos, Greece. The Organizing Committee was set up by J. Myritzis, S. Cotsakis, K. Kokkotas, and N. Stergioulas. The meeting attracted increased international participation and several invited and contributing talks presented original research both theoretical and experimental on Cosmology, Mathematical Relativity, Relativistic Astrophysics, Gravitational-Wave Detection and Quantum Gravity, including surveys of important recent results/ directions. It was attended by about 45 participants and half of them were young researchers, in addition to senior Greek relativists working in different universities and research centers around the country.

The following invited speakers presented work in the designated areas: *I. Antoniadis*, Extra dimensions and possible modifications of Newton's law; *Y. Choquet-Bruhat,* Global properties of solutions of Einstein equations with one Killing field; *D. Christodoulou*, The development of singularities in spherically symmetric spacetimes; V. *Ferrari,* Imprint of the equation of state of dense matter on gravitational waves emitted by oscillating neutron stars; *J. Lidsey*, Inflation, Braneworlds and Dark Energy; *B.S. Sathyaprakash*, Gravitational Wave Observations: Current Status and Future Prospects. At the end of the Meeting there a very interesting talk addressed to the general public on "Hidden Extra Dimensions" was delivered by I. Antoniadis.

The intensive pace of the lectures was relieved by social hours and a banquet at a beautiful restaurant by the sea. The fine weather allowed many discussions and social activities to be held in the open air symbolizing to us the open and friendly nature of this series of Meetings and the location. The participants had the opportunity to appreciate the natural beauty and the long cultural tradition of this island. The conference ended with an afternoon excursion to the picturesque village of Mythimna with lunch at a traditional Greek tavern by the beach.

The Proceedings of the conference are scheduled to be published in the Conference Series of the Journal of Physics, which is the new IOP electronic Proceedings Journal.

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