



PROPOSITION DE PROGRAMME DE RECHERCHE

Période Ete 2004

Type de programme : (cocher la case correspondante) Court terme <input type="checkbox"/> Long terme <input checked="" type="checkbox"/>	
Titre du programme : Long term monitoring of γ Doradus stars in the COROT framework Résumé du programme : <p>The scientific objectives of COROT is to provide continuous data for asteroseismology. The central program will concern both Solar-like and δ Scuti stars, which are known to exhibit p-modes. However, the most internal layers are best probed by g-modes which propagate deeper. These g-modes have been detected in various pulsating classes, one being located between δ Scuti stars and the Sun: the γ Doradus stars.</p> <p>This proposal concerns a long term spectroscopic monitoring, completed by photometric measurements, devoted to these stars. A preliminary survey have already been published, and we would like to focus on the frequency spectrum and mode identification, with the objective that at least one star will be selected in the "Sismo" COROT field, while our team is responsible for the γ Doradus stars in the COROT Add. Prog.</p>	
Nombres de nuits demandées : 34 Lune : <input type="checkbox"/> NL <input type="checkbox"/> PQ <input type="checkbox"/> PL <input type="checkbox"/> DQ	
Dates préférentielles : 1 : April-August 2 :	
Périodes à éviter :	
Chercheur principal : P. Mathias Adresse : Observatoire de la Cote d'Azur Dépt. GEMINI BP 4229 F-06304 Nice Cedex 4 E-mail : mathias@obs-nice.fr Tél. : 04 92 00 31 78 Fax : 04 92 00 31 38	Collaborateurs : "Physique Stellaire" team (OCA) E. Poretti and the Merate SOUND group, Italy C. Aerts, KU Leuven, Belgium A. Arellano Ferro, UNAM, Mexico L. Eyer, Observatoire de Genève, Switzerland R. Garrido, Granada, Spain W. Weiss, U. Vienna, Austria

Remplir un formulaire par programme. En faire un fichier Post-Script à envoyer a cneiner@rssd.esa.int avant le 15 janvier 2004.

Titre du programme :

Long term monitoring of γ Doradus stars in the COROT framework

S'agit-il de la poursuite d'un programme antérieur ?

OUI

NON

Nom du chercheur principal :

P. Mathias

1 Justification scientifique du programme

Remplacez votre programme dans le contexte scientifique international actuel (avec les références bibliographiques nécessaires) et mettez en relief les questions auxquelles les observations demandées sont appelées à répondre.

Physics of the inside of the stars is not well known. This poor knowledge implies serious uncertainties not only about the modelisation of the inner structure and the stars evolution, but also in all fields of astrophysics using these results. This problem can be partially solved with the use of asteroseismology: the frequency oscillation spectrum and the identification of the excited modes lead to important results concerning the extension of the core, internal rotation and location of the tachocline, measure of the sound velocity in the internal layers...

Yet, asteroseismology requires intensive monitoring as well as a large precision in the measures. These objectives will be fulfilled by the COROT mission (<http://www.astrsp-mrs.fr/projets/corot/>) which will observe δ Scuti and Sun-like stars during runs of 150 days. The COROT satellite is planned to be launched in early 2006.

However, up to now, the modes detected in these stars belong to p -modes, propagating preferentially in the outer layers. But it should be valuable to monitor also stars presenting g -modes which propagate deeper. This is why g -modes are actively searched in our Sun (IRIS, GONG, BISON, SOHO...) with no success until now. Actually, these important modes have been detected in other stars (DA and DB white dwarfs, SPBs and γ Doradus essentially). Among them, γ Doradus stars match very well the scientific aspects investigated by COROT, i.e. pulsation in solar-like and classical δ Scuti stars. Indeed, in a recent workshop (Paris 2000, Marseille 2003) the γ Doradus stars have been selected as very promising targets in the framework of COROT Additional Programs. These latter, lasting several weeks, will be devoted to "interesting objects".

The γ Doradus stars are indeed "interesting objects". They constitute a new class of pulsating variables discovered only recently. These objects are thought to exhibit multiperiodic high-order low degree g -mode oscillations with periods in the range of 0.5 – 3 days (see e.g. Kaye et al. 1999, PASP 111, 840). The presently proposed destabilization mechanism is explained by the modulation of the radiative flux by convection at the base of a deep envelope convection zone (Guzik et al. 2000, ApJ 542, L57, Warner et al., 2003, ApJ 593, 1049).

Much effort is currently made to find new members of this group, to constrain their pulsation characteristics and their position in the HR diagram, especially the γ Doradus star's red border in relation with solar-like star's blue border. Indeed, the number of bona fide members is still low, and show quite a large variety in their observational behaviour (see e.g. <http://www.astro.ac.at/dsn/gerald/gdorlist.html>). For instance, their observational instability strip partly covers that of δ Scuti stars, and at least one γ Doradus variable also pulsates in δ Scuti p -modes (Handler et al., 2002, MNRAS 333, 262). In this case, these "hybrids" are particularly important for asteroseismology since both the upper and deeper layers are probed by respectively p - and g -waves. A few stars with surface abundances peculiarities have also been observed to exhibit γ Doradus variations, e.g. λ Bootis stars (Gray & Kaye 1999, AJ 118, 2993) or Am stars (Gray & Kaye, in preparation).

A few candidates (12 stars provided by L. Eyer) have been observed spectroscopically with ELODIE in the framework of the COROT preparation mission (Catala, private communication). However, generally only 2 spectra have been taken per object (whatever the nature of this latter and with magnitude $V \leq 6$), but separated by only 0.5–1h, hence much shorter compared to the periods awaited in γ Doradus stars. The aim of our program is to confirm the suspected γ Doradus variables and try to derive their pulsation frequency as well as the amplitude of the involved modes, in order to choose the best targets to be selected for the COROT Additional Programs. Moreover, independently from COROT, this first spectroscopic survey will bring new insights in the knowledge of these stars: constrains on their position in the HR diagram, confrontation with the new proposed driving mechanism, mode identification performed with the moment method (Aerts 1996, A&A 314, 115).

Preliminary results performed on a sample of about 60 stars showed that binarity seems to play an important role (Mathias et al. 2004, A&A, in press). Therefore, an additional objective of this proposal is to derive the binary ephemeris.

2 Justification de la faisabilité du programme avec le reseau ARAS

Indiquez ce qui doit être réellement observé et ce qui doit ressortir des observations (notamment en terme de rapport signal/bruit, résolution spectrale, etc) afin de démontrer que le programme est réalisable avec l'instrumentation ARAS.

The main objective of this program is to confirm the γ Doradus character of a sample of about 70 candidates observable from the northern hemisphere. The list of these candidates has been established from mainly <http://www.astro.ac.at/dsn/gerald/gdor> and completed from other references (Eyer & Aerts 2000, A&A 361,201 and E. Poretti, S. Martin and R. Garrido from the STARE photometric survey). See also the different internal reports of the COROT Asteroseismology Working Groups). These stars have been mainly detected and monitored with photometric instrumentation (including Hipparcos), but scarcely monitored in spectroscopy. When available, the measured radial velocity amplitude is between a few and 10 km.s^{-1} (see e.g. Zerbi et al. 1999, MNRAS 303, 275). Such a precision should be easily obtained with MUSICOS, especially when deriving velocities from a correlation profile. Moreover, the low-degree (ℓ is usually below 4, e.g. Zerbi et al. 1997, MNRAS 292, 43) g -modes are able to produce line profile variations allowing the identification of the involved modes. Such a method performed with correlation profile has already been applied on δ Scuti stars (e.g. Mathias & Aerts 1996, A&A 312, 905). The advantage of spectroscopy with respect to photometry is that the azimuthal number m may also be unambiguously determined. Hence photometric survey alone is not sufficient for a complete mode identification. The run will consist in observing each candidate at least once a night in order to get the time scale of the variation, and the number of present excited modes. A S/N ratio above 150 together with a spectral resolution around 35 000, will allow us to apply the moment method (Aerts 1996, A&A 314, 115) to determine the basic pulsation (ℓ and m , pulsation amplitude) and stellar (rotation velocity, inclination angle, intrinsic profile width) characteristics. In addition, we would like to confirm the "hybrid" characteristics of 2 candidates, by detecting periods on two different scales: short periods (few hours) for p -modes, and long periods (few tens of hours) for g -modes. Of course, this requires more intensive monitoring, and a few nights will be entirely devoted to these objects.

3 Justification du nombre de nuits demandées

- *Sont à prendre en compte le nombre d'objets du programme, le temps d'intégration par objet (y compris les étoiles standard) pour obtenir le rapport signal/bruit requis, et les temps d'étalonnages instrumentaux.*

There are about 30 candidates to monitor (see Sect. 5). As previously said, the aim is first to establish the variability of the star, and then to get its frequency spectrum. Taking into account the typical awaited pulsation frequencies, a minimum of 1 spectrum per night should be obtained. If these stars were purely monophasic, a run of typically one week would be enough, but they are usually multiphasic, with 3 or 4 periods often detected. Consequently, and despite the requested long-term observations, a long time basis, of the order of 2 months per star if each star is observed once a night, is necessary to achieve this goal. Two nights are also required for each of the 2 hybrid δ Scuti/ γ Doradus candidates, in order to detect the short time scale variations (a few hours).

This proposal will be rather a "discovery" run, the objective being the confirmation of the γ Doradus character from a spectroscopic point of view, with the determination of at least the main frequency. Some stars may also be rejected (too low signal, not γ Doradus). The selected ones will be the more intensively monitored.

During each of the requested periods, we will observe nearly 30 stars. For a magnitude between 5 and 9, the exposure time will be in the range 30 min – 90 min to ensure a S/N ratio above 150. Thus, only a period of 3 nights will monitor the complete set. Consequently, we ask at least 5 spectra for each star per period i.e., 15 days twice a semester. And if 1 night per hybrid star is added each period, the total number of nights is 34.

- *S'il s'agit d'un programme à long terme, indiquez le nombre de nuits déjà attribuées au programme, et justifiez le nombre de nuits supplémentaires nécessaires à son achèvement.*

Our total sample contains about 40 stars (among which 30 are observable in a given semester) that can be observed from St Veran. Because of the length of their intrinsic pulsation periods, and their multiphasic character, the

time basis of the monitoring has to be the largest one. As said above, two months per star imply two years in order to get both the frequency spectrum and the mode identification.

However, the run should be smaller for the second year since some candidates will be rejected (see Sect.7).

4 Propriété des données

- *Ce programme nécessite-t-il de conserver la propriété des données au-delà de la période normale de 1 an ? Si oui, justifier.*

- *Ce projet fait-il l'objet d'une campagne couplée à d'autres moyens d'observations ? Lesquels ?*

In addition, simultaneous photometric data are also planned at Granada (Spain), San Pedro Martir (Mexico) and La Palma (Canary, Spain).

5 Coordonnées équatoriales (2000) et magnitudes des astres à observer

Cette information est indispensable ; ajoutez une annexe si nécessaire.

Please note that among the stars listed below, 2 of them (HD 167858 and HD 175337) belong to the Exploratory Programme of Seismology in Scenario 3 (COROT: Preliminary Work on Target Selection II, 15/02/2001).

γ Doradus candidates									
α	δ	V	Spec. Type	Name	Month				
00 02 02.62	-02 45 58.2	6.9	A3	HD 224945	8				
00 07 37.48	+53 31 35.6	8.35	F0	HD 277	5,8				
00 31 49.75	+04 50 46.2	8.00	F0	HD 2842	8				
01 12 53.89	+51 36 08.5	7.3	A5	HD 7169	5,8				
01 33 45.48	+60 37 23.2	8.17	F0	HD 9365	5,8				
03 48 51.56	+11 42 31.7	8.20	F0	HD 23874	8				
05 06 40.63	+51 35 51.8	4.980	F0V	HD 32537	5,8				
06 44 11.75	+36 59 38.4	7.50	F0	HD 48271	5,8				
07 45 42.34	+39 32 49.0	7.15	F0	HD 62454	5,8				
08 15 42.09	+66 10 32.1	7.0	F2V	HD 68192	5,8				
08 19 31.76	+35 02 44.4	7.169	A5	HD 69715	5				
08 27 40.09	+67 58 26.8	8.121	F0	HD 70645	5,8				
09 24 03.26	+61 46 22.9	8.3	F0V	HD 80731	5				
09 58 26.04	+27 45 32.4	6.480	F3V	HD 86358	5				
11 32 12.88	+38 55 33.0	7.99	A _m	HD 100215	5				
12 08 26.08	+48 58 06.6	7.9	A5	HD 105458	5,8				
12 24 56.93	+42 51 17.1	7.14	F2V	HD 108100	5,8				
13 06 22.71	+22 16 47.6	6.830	F0	HD 113867	5,8				
13 17 27.33	-10 32 46.6	6.890	F0	HD 115466	5				
14 12 33.46	-09 54 00.3	7.16	F0	HD 124248	5				
17 01 40.11	+75 17 51.0	6.176	F0IV-V _n	HD 155154	5,8				
18 01 33.20	+11 17 08.7	7.02	F2IV-V	HD 164615	5,8				
18 17 04.84	+01 00 20.6	6.61	F2V	HD 167858	5,8				
18 32 47.86	+24 40 45.3	7.74	F0	HD 171244	5,8				
18 44 53.13	+57 05 17.2	8.11	F2	HD 173977	5,8				
18 54 54.36	+01 07 17.7	7.37	F5	HD 175337	5,8				
20 27 02.27	+49 23 00.1	5.736	F0V	HD 195068	5,8				
21 47 04.76	+17 11 38.5	6.196	F3V	HD 207223	5,8				
22 18 51.27	+04 08 35.3	9.12	F0	HD 211699	5,8				
23 07 28.72	+21 08 03.3	5.964	A5V	HD 218396	5,8				
23 35 37.53	+14 35 37.2	7.6	A3	HD 221866	5,8				
23 59 35.04	-01 50 59.7	7.5	F0	HD 224638	8				
Hybrid δ Scuti/ γ Doradus candidates									
18 00 29.01	-03 41 25.0	4.62	F2IV	HD 164259	5				
18 36 39.07	+06 40 18.5	5.43	F3V	HD 171834	5,8				

Column labelled "month" displays the month the star can be observed if the observations are not spread on the whole semester but identified as discrete periods. It is computed in such a way that the air mass is below 1.5.

6 Attributions précédentes

Liste des programmes ARAS précédents dont a bénéficié le demandeur au cours des trois dernières années, et rapport succinct sur les résultats obtenus.

None

7 Publications

Liste des 5 publications (recentes) les plus pertinentes de l'équipe proposante, liées au projet envisagé.

- 20 CVn: a Monoperiodic Radially Pulsating delta Scuti Star M. Chadid, J. De Ridder, C. Aerts, P. Mathias: 2001, A&A, 375, 113

- A New Analysis of the Radial Velocity Variations of the Eclipsing and Spectroscopic Binary. EN Lacertae H. Lehmann, P. Harmanec, C. Aerts, H. Bozic, P. Eenens, G. Hildebrandt, D. Holmgren, P. Mathias, G. Scholz, M. Slechta, S. Yang: 2001, A&A, 367, 236
- Atmospheric Abundances in Post-AGB Candidates of Intermediate Temperature. A. Arellano Ferro, S. Giridhar, P. Mathias: 2001, A&A, 368, 250
- A Li-rich Post-AGB Star HD 172481 S. Giridhar, A. Arellano Ferro, P. Mathias: 2001, BASI, 29, 289
- Activity in the SPB Star 53 Piscium. J.-M. Le Contel, P. Mathias, E. Chapellier, J.-C. Valtier: 2001, A&A, 280, 277
- Spectroscopic Monitoring of 10 New Northern Slowly Pulsating B Stars Candidates from the HIPPARCOS Mission. P. Mathias, C. Aerts, M. Briquet, P. De Cat, J. Cuypers, H. Van Winckel, J.-M. Le Contel: 2001, A&A, 379, 905
- Spectroscopic Mode Identification for the Slowly Pulsating B Star. HD 147394 M. Briquet, C. Aerts, P. Mathias, R. Scuflaire, A. Noels: 2003, A&A, 401, 281
- Preparing the COROT Space Mission: Incidence and Characterisation of Pulsation in the Lower Instability Strip. E. Poretti, R. Garrido, P.J. Amado, E. Poretti, R. Garrido, P.J. Amado, K. Uytterhoeven, G. Handler, R. Alonso, S. Martin, C. Aerts, C. Catala, M.J. Goupil, E. Michel, L. Mantegazza, P. Mathias, et al.: 2003, A&A, 406, 203
- Mathias P., Chapellier E., Le Contel J.-M., Jankov S., Sareyan J.-P., et al., 2003, Proceedings of the 2nd Workshop, Ed. F. Favata, Palermo
- Mathias P., Chapellier E., Le Contel J.-M., Jankov S., Sareyan J.-P., et al., 2003, COROT Seismology Working Group, Internal Report CW4
- Asteroseismology of the beta Cephei star nu Eridani: spectroscopic observations and pulsational frequency analysis. C. Aerts, P. De Cat, G. Handler, U. Heiter, L.A. Balona, K. Krzesinski, P. Mathias et al.: 2004, MNRAS 347, 463
- HD173977: an Ellipsoidal delta Scuti Star Variable. E. Chapellier, P. Mathias, R. Garrido, J.-M. Le Contel, J.-P. Sareyan, I. Ribas, L. Parrao, A. Moya, J. Pena, M. Alvarez: 2004, A&A, en révision
- Multi-site, multi-technique survey of gamma Doradus candidates I- Spectroscopic results for 59 stars. P. Mathias, J.-M. Le Contel, E. Chapellier, S. Jankov, J.-P. Sareyan et al.: 2004, A&A, in press

Date : January 13, 2004

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- Vous ne devez remplir qu'un seul formulaire par programme
 - Les informations concernant ARAS sont disponibles sur <http://astrosurf.com/aras>
 - Les publications basées sur des observations effectuées avec les telescopes associés à ARAS doivent en faire mention par une note dans le titre.
 - Les publications basées sur des observations effectuées avec ARAS doivent avoir ARAS comme co-auteur.
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