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PETICIÓN DE TIEMPO DE OBSERVACIÓN (CAT NOCTURNO)**CAT Español**

Observatorios del Roque de Los Muchachos y del Teide

1. Título**A spectroscopic census of northern Gaia ultracool dwarfs****2. Datos personales****2.1. Investigador principal**

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2.3. Persona de contacto**Nombre:** José Antonio Caballero Hernández**Dirección:** ESPAÑA**Centro:** Centro de Astrobiología - INTA-CSIC**Teléfono:** (+34)918131506**Fax:** (+34)918131160**E-mail:** caballero@cab.inta-csic.es**3. Resumen del programa**

We propose to complete the spectroscopic census of all L dwarfs that will be observed by the Gaia satellite. Our international team aims to determine radial velocities, spectral indicators and limits on the rotational velocities and abundances, which will be used to: (i) refine current, and discover new, correlations of physical characteristics with spectra; (ii) confirm young moving group and companion objects; (iii) test and improve the Gaia astrometric parameter determination for these objects; and (iv) search for spectroscopic binaries. The Osiris low-resolution spectra will complement X-Shooter and SpeX data and focus on the activity and metallicity features in the optical of the northern L dwarfs. All these spectra and derived quantities will be made available in a public virtual observatory-compliant archive.

4. ¿Es tiempo de colaboración con GTC?

No

5. Campo de investigación

Estrellas de Baja Masa Objetos Subestelares y

6. ¿Es continuación de programa que obtuvo tiempo? No**7. ¿Es este programa parte de un trabajo de tesis? No**

8. ¿Necesita tiempo en semestres siguientes? Sí

9. ¿Es de larga duración? No

10. Tiempo de observación solicitado

Telescopio	Instrumento	Sem.	Noches/Di	Horas	Luna	Fechas óptimas	Fechas imposibles
GTC	Osiris			20	A	20150301-20150831	
Cfg. instr.: LongSlit Spectroscopy			I. 2ario:		I. visit.:		
Modo Obs.:	Colas	Seeing:	0	Cobertura:	Cualq.	Vapor de agua:	

10.1. Justificación de fechas imposibles

There are no impossible dates

11. Comentarios

There is a very similar submitted proposal for X-Shooter at the Very Large Telescope, led by Richard L. Smart at the Osservatorio Astrofisico de Torino-INAF. The current Osiris observations complement the X-Shooter proposal at lower resolutions in the northern hemisphere and the optical range; the near-infrared range will be taken from public IRTF SpeX spectra. The joint team that will reduce, analyze, exploit and make public the data is larger than shown in the list of co-Is. Because of the relative brightness and homogeneous distribution in the sky of targets, moderate weather and Moon restrictions, and flexibility of implementation (i.e. shots of less than 30 min with the available grism), this is a filler program very easy to accomplish at the GTC.

12. Tiempos anteriores concedidos como IP/Col en los últimos 3 años

12.1. CAT Español

129-WHT31/14A Identifying the ultracool population of the Pleiades cluster

Comentario:* Spectroscopic follow-up of L- and T-type, proper motion member candidates in the Pleiades, Zapatero Osorio et al. (2014a, A&A, in press)

* Search for free-floating planetary-mass objects in the Pleiades, Zapatero Osorio et al. (2014a, A&A, 568, A77)

* Search for Pleiades T dwarfs, Gálvez-Ortiz et al. (2013, MmSAI, 84, 945)

Publicaciones:2014A&A...568A..77Z 2013MmSAI..84..

161-INT11/14A One thousand M dwarfs

Comentario:Obtained a wealth of good signal-to-noise spectra (>700), now being reduced and analyzed. Because of misunderstanding with CAT, no second semester was asked for nor awarded, which impacted in the completeness of the sample. Publication schedule delayed while awaiting for new optical spectroscopy being collected with CAFOS at the 2.2 m Calar Alto (Oct. 2014)

Publicaciones:

136-Mercator2/13A Calibrating the metallicity of M dwarfs with wide visual binaries

Comentario:Analysis in progress.

- CARMENES at PPVI. 5. Calibrating the metallicity of M-dwarfs with wide visual binaries. D. Montes, et al. Proceedings of Protostars and Planets VI (15 - 20 July 2013, Heidelberg, Germany)

Publicaciones:2013prpl.conf2K022M

35-Mercator2/12B Calibrating the metallicity of M dwarfs with wide visual binaries

Comentario:Analysis in progress (8-11 November 2012. 50% bad weather conditions).

- CARMENES at PPVI. 5. Calibrating the metallicity of M-dwarfs with wide visual binaries. D. Montes, et al. Proceedings of Protostars and Planets VI (15 - 20 July 2013, Heidelberg, Germany).

Publicaciones:2013prpl.conf2K022M

52-IAC808/12B R-band photometry of M dwarfs in the CARMENES input catalogue

Comentario:* Cool dwarfs in wide multiple systems. Paper 5: New astrometry of 54 wide pairs with M dwarfs, Cortés-Contreras et al. 2014, The Observatory, in press (to be published in Nov. 2014 issue)

Publicaciones:

63-TCS5/12B Search and confirmation of M dwarf binaries from the CARMENES sample using FastCam

Comentario:Most of the sample observed. Preliminary results presented:

* Cortés-Contreras et al. 2013, hsa7, CARMENES. V. M dwarfs in multiple systems

* Caballero et al. 2013, prpl, CARMENES at PPVI. CARMENCITA Herbs and Spices to Help you Prepare a Genuine Target Sample

Paper for A&A by Cortés-Contreras, Béjar, Caballero et al. in prep. Other unpublished contributions:

Search and confirmation of M dwarf binaries from the CARMENES sample using FastCam

* Cortés-Contreras et al. 2014, Preparation of the CARMENES input catalogue. Multiplicity of M dwarfs from tenths of arcseconds to hundreds of arcminutes, Cool Stars 18, in press

* Béjar et al., 2012, Proceedings of the Cool Stars 17, The 17th Cool Stars, Stellar Systems and the Sun workshop (24 - 29 June 2012, Barcelona, Spain)

Publicaciones:2013prpl.conf2K020C 2013hsa7.conf..646C

36-Mercator2/12A Calibrating the metallicity of M dwarfs with wide visual binaries

Comentario:Part of the sample observed. Preliminary results presented:

* Montes et al. 2012, Proceedings of the Cool Stars 17, The 17th Cool Stars, Stellar Systems and the Sun workshop (24 - 29 June 2012, Barcelona, Spain)

* Montes et al. 2012, Proceedings of the IAU Symposium 293 (27 - 31 August 2012, Beijing, China)

* CARMENES at PPVI. 5. Calibrating the metallicity of M-dwarfs with wide visual binaries.

D. Montes, et al. Proceedings of Protostars and Planets VI (15 - 20 July 2013, Heidelberg, Germany)

Publicaciones:2013prpl.conf2K022M

56-TCS5/12A Binarity in M dwarfs using FastCam. The sample selection for CARMENES

Comentario:Most of the sample observed. Preliminary results presented:

* Cortés-Contreras et al. 2013, hsa7, CARMENES. V. M dwarfs in multiple systems

* Caballero et al. 2013, prpl, CARMENES at PPVI. CARMENCITA Herbs and Spices to Help you Prepare a Genuine Target Sample

Paper for A&A by Cortés-Contreras, Béjar, Caballero et al. in prep. Other unpublished contributions:

* Cortés-Contreras et al. 2014, Preparation of the CARMENES input catalogue. Multiplicity of M dwarfs from tenths of arcseconds to hundreds of arcminutes, Cool Stars 18, in press

* Béjar et al., 2012, Proceedings of the Cool Stars 17, The 17th Cool Stars, Stellar Systems and the Sun workshop (24 - 29 June 2012, Barcelona, Spain)

Publicaciones:2013hsa7.conf..646C 2013prpl.conf2K020C

52-INT5/11B Spectral characterisation of new and poorly-known late-type dwarfs identified with VO tools

Comentario:* Search for Bright Nearby M Dwarfs with Virtual Observatory Tools, Aberasturi et al. 2014, AJ, 148, 36

Publicaciones:2014AJ....148...36A

155-TCS11/11B Binarity of M dwarfs using FastCam. The sample selection for CARMENES

Comentario:Most of the sample observed. Preliminary results presented:

* Cortés-Contreras et al. 2013, hsa7, CARMENES. V. M dwarfs in multiple systems

* Caballero et al. 2013, prpl, CARMENES at PPVI. CARMENCITA Herbs and Spices to Help you Prepare a Genuine Target Sample

Paper for A&A by Cortés-Contreras, Béjar, Caballero et al. in prep. Other unpublished contributions:

* Cortés-Contreras et al. 2014, Preparation of the CARMENES input catalogue. Multiplicity of M dwarfs from tenths of arcseconds to hundreds of arcminutes, Cool Stars 18, in press

* Béjar et al., 2012, Proceedings of the Cool Stars 17, The 17th Cool Stars, Stellar Systems and the Sun workshop (24 - 29 June 2012, Barcelona, Spain)

Publicaciones:2013hsa7.conf..646C 2013prpl.conf2K020C

12.2. Acuerdo IAC/Florida

12.3. Acuerdo IAC/México

12.4. CAT México

12.5. IAC Nordic

13. Fecha de envío

viernes, 3 de octubre de 2014

S. Scientific Justification

S.1. Scientific Objectives (Bibliographic references and diagrams in the next page)

Summary We propose to complete the medium resolution spectroscopy census of all known L dwarfs that are being observed by Gaia. From these spectra we will determine radial velocities, spectral indices and abundances/rotational velocities limits. The scientific applications are widespread e.g.: identify unresolved binaries; investigate peculiar objects; constrain the space density; refine models; look for moving group candidates; search for, and calibrate, age indicators; find bolometric luminosities and temperatures. These are the brightest L dwarfs in the sky so having Gaia astrometry and large wavelength coverage spectra will make this the defining sample for future studies of L dwarfs.

What and why of L dwarfs: L dwarfs are a mixture of ultracool sub-stellar objects that do not burn hydrogen and the lowest mass hydrogen fusing stars. They have spectra dominated by broad molecular absorption bands primarily due to water and methane. The current census of L dwarfs is over 1000, but with the new surveys current expectations is that 10⁶ will be found in the next few years. These objects are the link between stars and giant planets, sharing characteristics with both - e.g. like planets they do not fuse hydrogen but like stars they probably form directly from clouds and emit their own light generated by slow gravitational collapse.

L dwarfs are extremely long lived but, from their birth these objects are continually cooling, hence their luminosity and spectral type are a strong function of age. For example, a 0.05 solar mass object starts its life as a late M dwarf, from 0.1 to 1 Gyr it transverses the L dwarf spectral types and then continues into the late T types. While this property, of changing spectral type, complicates our understanding of these objects, when we have calibrated age indicators, they will become powerful tools to understand the evolution of the galaxy. Finally, L dwarfs overlap in color space with directly imaged planets [1,2]. This implies that atmospheric processes in planets and L dwarfs are similar and increased understanding in the latter can be applied to the former. The large Xshooter spectral coverage is ideal for L dwarfs which have significant optical and IR flux. L dwarfs in Gaia: The ESA cornerstone mission Gaia launched on December 19th 2013 will revolutionise astronomy observing objects as diverse as minor planets, stars, galaxies out to QSOs and impacting almost all areas of astronomy. The limiting magnitude will be between 20-21 in the Gaia G band (close to Cousins R). Using the colors of known L dwarfs and published transformations we estimate that 500 L0 to L5 dwarfs and a handful of later than L6 dwarfs with 2 T dwarfs, Luhman 16Ab [3] and Epsilon Indi Ba [4] will be observed by Gaia, increasing the current sample with distances by a factor of between 5 and 10. These will have parallaxes with precisions of better than .2 mas providing distances with relative errors of less than 1% and tangential velocities at the level of 10-30m/s. In this proposal we will concentrate on the L0 to L5 sample as the later types, being the brightest examples of their respective classes, are already well studied. The 500 L0 to L5 dwarfs with Gaia parallaxes, proper motions and photometric coverage will be the defining sample for future exploitation of these objects. As they are so close the perspective acceleration will change both the parallax and the proper motion over the time frame of the mission providing "astrometric" radial velocities with errors of 10-20 km/s. The radial velocities found in this proposal will be more precise and will be used quality check of the Gaia results. For individual objects our radial velocities will be needed to obtain the best astrometric solutions [e.g. 5].

Scientific Application This large, magnitude limited, sample of L dwarfs will have from Gaia tangential velocities with errors of a few m/s, distances with relative errors of less than 1% and millimagnitude optical photometry. Many of the problems that have plagued the identification of benchmark systems [6], binaries, peculiar objects moving group candidates, space density distributions (see fig. 1), effective temperatures, luminosities and relations to spectral types will be removed. However, the inhomogenous low resolution spectra available today will permit the determination of radial velocities, spectral indices and metallicity indicators which require at least Xshooter level resolution.

This proposal will iterate between models and full simulations with the Xshooter spectral composition, age and mass indicators and the Gaia parameters to construct a coherent, consistent picture of the L dwarf population in the local solar neighbourhood. The key to this analysis will be to simultaneously satisfy as many constraints as possible, many of which are only possible with Xshooter spectra, e.g.:

- confirmation of moving group members which requires radial velocity errors of less than 1-2 km/s as they overlap in kinematical parameter space [7].
- discriminate between sub-stellar and brown dwarf objects via the Li I test which requires Li I and H alpha equivalent widths. [10]
- measure spectral features needed to constrain and calibrate age and mass indicators, e.g. the shape of the H-band peak [9], the FeH_z, VO, KI and NaI indices [11 and figure 1].
- determination of space motions for kinematical age constraints. [8]
- spectra for understanding peculiar objects such as seen in ULAS2227-00 [12] a very red L dwarf with an excess of dust in the photosphere as shown in figure 1 and 2MASS 0355+11 [13].

References

1. Delorme et al. 2013 A&A 553
2. Faherty et al. 2012 AJ 145
3. Luhman 2013 ApJL 743
4. Scholz R. D., et al. 2003 A&A 398
5. de Bruijne & Eilers 2012 A&A 546
6. Pinfield et al. 2006 MNRAS 368
7. Gálvez-Ortiz et al. 2010 MNRAS 409
8. Soderblom ARAA 2010, 48
9. Lucas et al. 2001 MNRAS 695
10. Kirkpatrick et al. 2008, ApJ, 689
11. Allers & Liu 2013, ApJ, 772
12. Cruz et al. 2009, AJ, 137
13. Marocco et al. 2014 MNRAS 439
14. Faherty et al. 2012 AJ 145
15. Deacon & Hambly 2006, MNRAS, 371
16. Barnes et al. 2012, MNRAS, 424

Graphics

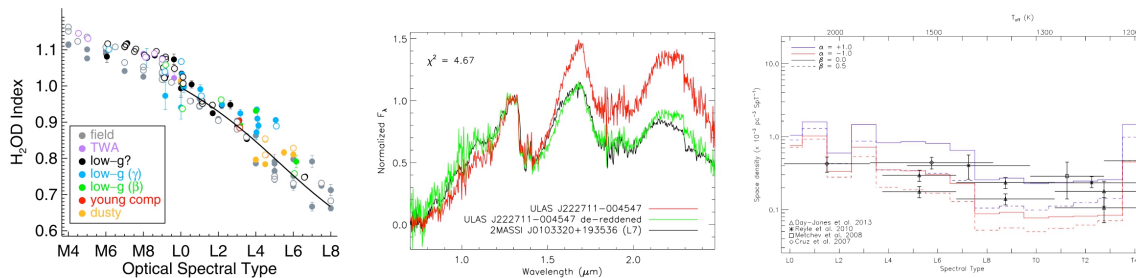


Figure 1: *Left panel:* An example of the use of spectral indices as age and mass indicators (Allers & Liu 2013). *Middle panel:* The observed spectra of ULAS2227 (red lines), the standard L7 2MASS0103 and a de-reddened spectra of ULAS2227 (Marocco et al. 2014). *Right panel:* A comparison between measured space densities of L and T dwarfs compared to models (Deacon & Hambly 2006). None of the measurements consistently follow the models and in the Day-Jones measurements we show the difference of assuming two different binary fractions.

R. Enumerate references from the research team related to this proposal (no more than 6 references)

1. *Gaia and brown dwarfs from Spain*, **Caballero, J. A.**, Proceedings of the GREAT-ESF workshop "Gaia and the unseen - the brown dwarf question", Torino, 24-26 March 2014, to be published in *Memorie della Societa' Astronomica Italiana (SAIt)*, eds. Ricky Smart, David Barrado, Jackie Faherty (eprint arXiv:1408.2421)
2. *Search for Bright Nearby M Dwarfs with Virtual Observatory Tools*, Aberasturi, M., **Caballero, J. A.**, Montesinos, B., Gálvez-Ortiz, M. C., Solano, E., Martín, E. L., 2014, AJ, 148, 36
3. *The extremely red L dwarf ULAS J222711-004547 - dominated by dust*, Marocco, F., Day-Jones, A. C., Lucas, P. W., Jones, H. R. A., Smart, R. L., Zhang, Z. H., Gomes, J. I., Burningham, B., Pinfield, D. J., Raddi, R., Smith, L. 2014, MNRAS, 439, 372
4. *High-resolution spectroscopic atlas of M subdwarfs. Effective temperature and metallicity*, Rajpurohit, A. S., Reylé, C., Allard, F., Scholz, R.-D., Homeier, D., Schultheis, M., Bayo, A. 2014, A&A, 564, A90
5. *NPARSEC: NTT Parallaxes of Southern Extremely Cool objects. Goals, targets, procedures and first results*, Smart, R. L., Tinney, C. G., Bucciarelli, B., Marocco, F., Abbas, U., Andrei, A., Bernardi, G., Burningham, B., Cardoso, C., Costa, E. et al. 2013, MNRAS, 433, 2054

6. *Stars and brown dwarfs in the σ Orionis cluster. III. OSIRIS/GTC low-resolution spectroscopy of variable sources*, **Caballero, J. A.**, Cabrera-Lavers, A., García-Álvarez, D., Pascual, S., 2012, A&A, 546, A59

T. Description of the observing plan, data reduction and analysis

T.1. Jusfitify the amount of requested time (number of targets to be observed and exposure time per target), prioritized target list, including coordinates, magnitude and other properties defining observing program. In the case of use of own equipments detail in attached sheets.

L dwarf name	α (J2000)	δ (J2000)	SpT / Group	J [mag]
J0015+3516	00 15 44	+35 16 02	L2.0	13.87
J0032+0219	00 32 05	+02 19 01	L1.5	14.32
J0036+1821	00 36 16	+18 21 10	L3.5	13.46
J0041+1341	00 41 54	+13 41 35	L0.0	14.45
J0043+2221	00 43 26	+22 21 24	L1sd	14.87
J0135+1205	01 35 35	+12 05 21	L1.5	14.45
J0147+3453	01 47 33	+34 53 11	L0.5	14.94
J0153+1404	01 53 54	+14 04 52	L0.0	15.20
J0213+4444	02 13 28	+44 44 45	L1.5	13.49
J0228+1639	02 28 42	+16 39 32	L0:	13.16
J0314+1603	03 14 03	+16 03 05	L0.0	12.52
J0345+2540	03 45 43	+25 40 23	L0.0	13.99
J0355+1133	03 55 23	+11 33 43	L5.0	14.05
J0404+4127	04 04 18	+41 27 35	L2.0	14.14
J0435+2115	04 35 35	+21 15 08	L0sd	15.01
J0500+0300	05 00 20	+03 30 50	L4.0	13.66
J0502+1442	05 02 13	+14 42 36	L0.0	14.27
J0530+6253	05 30 12	+62 53 25	L1.0	14.05
J0539-0059	05 39 51	-00 59 01	L5.0	14.03
...
J1354+5044	13 54 39	+50 44 50	L1.0	14.35

We tabulate above 20 of the roughly 170 L dwarfs that we have preliminary selected for observing with X-Shooter and Osiris. We split the full sample into two subsamples, one in the North, the other one in the South, with a tiny overlapping of ± 5 deg in declination. About two thirds of each subsample is observable every semester. Of the 50-60 L dwarfs, we will identify for Phase 2 the best 40 targets (the brightest ones and covering homogeneously in spectral type and right ascension). Besides, the final list will be refined when we have more knowledge of the magnitude limit of *Gaia*, the transformation of the *Gaia* optical system and and by comparing to what is already covered in the literature. This list is continually being updated and online at the IPERCOOL site.

From our previous experience with Osiris and the R1000R and R2500V grisms in filler mode with bad weather conditions (bad seeing, poor transparency) of red, faint objects towards Orion, we are confident that with moderate weather conditions (seeing < 2 arcsec, moderate transparency), we will get the necessary signal-to-noise ratio in about 1200-1500 s (which makes OBs/shots of 30 min).

T.2. ¿Has the group previous observational experience with similar instrumentation?

Yes No

T.3. Do extra time will be needed, once the program has been started?

Yes. We will apply for time in the following semester, for a complete coverage in right ascension of the targets.

T.4. Alternative Program: Title and short description. If the main program is very restricted regarding observing conditions, there must be a solid alternative program.

See Section T.

T.5. Other proposals when simultaneous observations are requested

Yes, we have a complementary proposal for X-Shooter at the Very Large Telescope.
See Section "11 Comentarios".

A. Are there other observations of the same targets in the telescope archive?

Yes No

A.2. If positive, justify the need for new observations.

Some targets might be observed previously with Osiris under other programmes (e.g., IPs: Zhenghua Zhang, Nicolas Lodieu, María Rosa Zapatero Osorio), as part of their investigations on L-type subdwarfs and standard typing for substellar objects in open clusters. A study of the data already public, both in the GTC database or any other one, is part of the complementary compilation of imaging and spectroscopic data for the eventual virtual observatory catalogue of "Gaia Ultracool Dwarfs".

C. Critical questions related to this program

This is a filler programme for GTC (not Target of Opportunity).