Highlights of Spanish Astrophysics VI, Proceedings of the IX Scientific Meeting of the Spanish Astronomical Society held on September 13 - 17, 2010, in Madrid, Spain. M. R. Zapatero Osorio et al. (eds.)

Protoplanetary discs of young VLMOs discovered in the IPHAS survey

L. Valdivielso[1,2], H. Bouy[3], and E. L. Martín[3,4]

[1] Instituto de Astrofísica de Canarias, C/. Vía Láctea s/n, E-38200 La Laguna, Tenerife, Spain
[2] Centro de Estudios de Física del Cosmos de Aragón, C/. General Pizarro 1, 44001 Teruel, Spain
[3] CAB (CSIC-INTA), Ctra. de Ajalvir km 4, 28850 Torrejón de Ardoz, Madrid, Spain
[4] Univ. of Central Florida, Dept. of Physics, PO Box 162385, Orlando, FL32816-2385, USA

Abstract

In a previous study, Virtual Observatory tools were used to cross-match the IPHAS catalogue with the 2MASS catalogue for searching young very low-mass objects. We defined photometric criteria to identify Hα emission sources with near-infrared colors similar to known young very low-mass stars and brown dwarfs. Spectral types have been derived for the 33 candidates that have spectroscopically confirmed Hα emission and spectral class M. Many objects also have weak NaI doublet, an indication of low surface gravity. Here we focus on a deeper study of the targets. We found that many of them display a clear excess in the Spitzer bandpasses, commonly associated with the presence of circumstellar material. Together with their strong Hα emission, which must be associated to accretion, the mid-infrared excesses confirm the youth of these objects.

1 Introduction

It is well stablished that young very low-mass objects (VLMOs) harbour accretion discs [3, 4, 14, 18] and the study of their properties provide constraints on models for their formation. The presence of discs around young objects can be detected as infrared excess emission above that expected for a stellar photosphere, due to the thermal emission of the circumstellar disc, on the spectral energy distribution (SED) [22]. Spitzer observations have proved to be a fundamental tool for identifying and studying young stellar objects with discs. In order to understand how they form, many ongoing searches of young VLMOs have been performed using Spitzer observations, in open clusters, young associations, and star forming regions ([1, 5, 10, 13, 15, 16, 19]).

Table 1: Spitzer archival data

P.I.	Program
George Rieke	58
Giovanni Fazio	40056
Joseph Hora	40184
Judy Pipher	20403
Lori Allen	30574
Luisa Rebull	20015
Neal Evans	174
William Reach	1017

The INT Photometric Hα Survey of the Northern Galactic Plane (IPHAS) allows us to select young accreting BD candidates in a very large area, away from stellar formation areas. In [21] we introduced our wide field photometric survey covering ~ 1600 deg^2 of the IPHAS survey. In that work, we presented low resolution spectroscopy of 113 photometrically-selected candidate VLMOs, of which 33 were confirmed by us to be young accreting low-mass M dwarf objects.

In the following we present the new photometry obtained from Spitzer data for some of the observed targets, we construct the SEDs and compare with mean SEDs derived for young star forming regions and confirm the presence of discs.

2 Spitzer photometry

We have searched for data on the Spitzer Space Telescope public archive and seventeen of them fell in the field of view of Spitzer observations. We have detections in five wavelength bands: the 3.6, 4.5, 5.8 and 8 μm bands of the Infrared Array Camera (IRAC; [9]) and the 24 μm band of the Multi-band Imaging Photometer for Spitzer (MIPS; [17]). The photometry extracted from these data is supplemented by J, H, and K_s-band photometry from the 2MASS point source catalogue [20] and the r', Hα and i'-band photometry from IPHAS catalogue [8, 11] resulting in data in eleven photometric bands spanning 0.6-24 μm. Table 1 gives a summary of the Spitzer programs and P.I. We retrieved the pipeline processed data and performed aperture photometry of the targets using standard procedures within the IRAF environment. For IRAC, we adopted different aperture radius and sky annulus depending on the target, the crowding of the field around the target and the mosaic scale. For MIPS, we used an aperture radius of 2.45 pixels (1 pixel = 2.45$''$) and a sky annulus between 2.45 and 5.31 pixels. A multiplicative aperture correction of 1.698 was applied to the MIPS 24 μm flux densities, to place the photometry on the calibration scale described in the MIPS data handbooks. The same procedure was applied to the IRAC flux densities according to the different apertures, and following the IRAC manual recommendations.

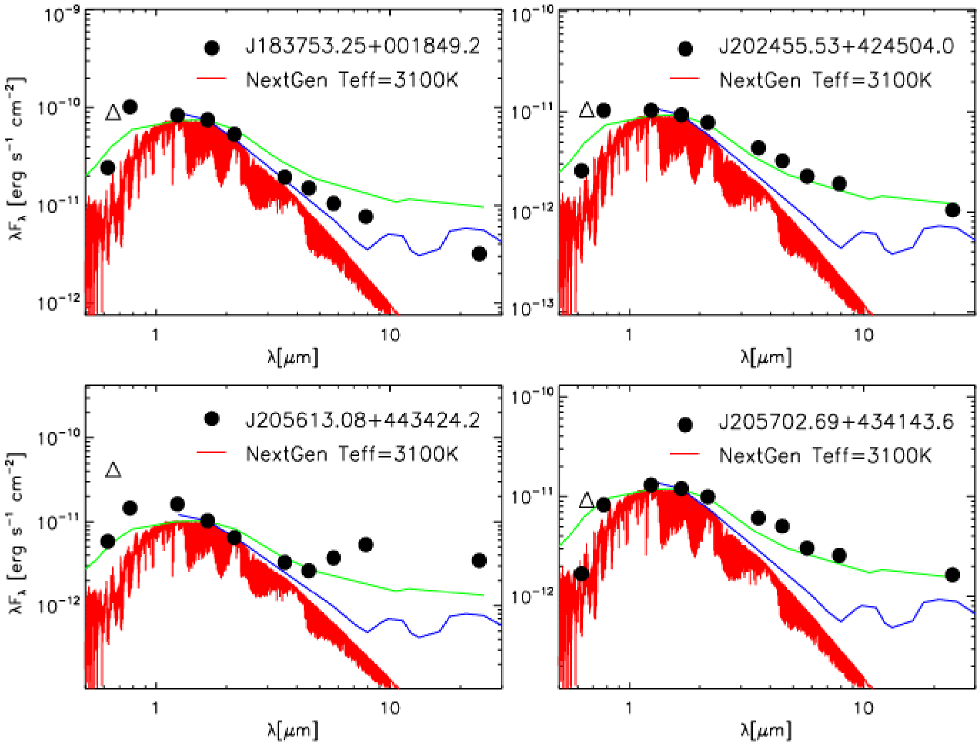

Figure 1: SEDs of four targets (black spots). Superposed are the median SED for near solar-mass (K5–M2) stars for Upper Sco [6] (blue) and Taurus [7] (green). The NextGen models of [2] (red), for the nearest effective temperature according to the spectral type of the target are superposed. All of them are normalized to H-band fluxes. Hα fluxes are represented by open triangles.

2.1 Spectral Energy Distributions

In Fig. 1 we show the extinction-corrected SEDs for some of the targets. Superimposed on the SEDs are the NextGen synthetic spectrum (derived using the method applied by [12]), as well as the median SEDs computed by [7] and [6], which are representative of low–mass stars (K5-M2 spectral types) in Taurus ($\sim$ 2–3 Myr) and Upper Scorpius (5 Myr). All spectra were normalized to our targets H band (1.65 μm) luminosity. It is worth noting that, although many of our objects may have spectral types later than M2, the expected differences between the median SEDs of K5–M2 and M3–M5 stars (as given in [6]) is smaller than 5% at the longest wavelengths (25 μm), being nearly null at shorter wavelengths $\sim$ 0% at 1.25 μm).

It is found that most of the sources display a clear excess in the Spitzer bandpasses, a phenomenon commonly associated with the presence of circumstellar material. These sources present SEDs very similar or intermediate between those of Upper Scorpius and Taurus low-mass class II members. Together with their strong Hα emission, which must be associated to accretion, and the weakness of the NaI doublet in their optical spectra, the mid-infrared excesses therefore confirm the youth of these objects.

The source J205613.08+443424.2 displays a peak at near infrared wavelengths, followed by a change in the slope between 3–5 μm. It has very red colours at long wavelengths. The double peak slope could be due to either: i) a transitional disc with an inner hole; ii) geometric effects, as a high inclination of the disc is known to produce such double peak SED [22].

3 Summary and conclusions

We have presented new results from observed low-mass objects candidates selected from large scale optical and NIR surveys. We combine the obtained photometry and make and study the SEDs of our sample.

From the SED analysis, we confirm the presence of circumstellar discs around all sources with available Spitzer photometry. Most of the SEDs present typical slopes of low-mass class II objects, with excesses intermediate between those reported for Taurus (< 3 Myr) and Upper Scorpius (5 Myr) members.

Of the seventeen sources, only three were previously identified as young low-mass star candidates, illustrating the advantages of Hα surveys for the search of young low and very low-mass stars.

Also, the IPHAS Hα photometry together with optical and near infrared photometry provides a very useful tool for selecting actively accreting objects.

Acknowledgments

This paper makes use of data obtained as part of IPHAS carried out at the INT as well as WHT, Nordic Optical Telescope (NOT) and 3m-Shane Telescope. The INT and WHT are operated by the Isaac Newton Group, NOT by NOTSA on the island of La Palma in the Spanish Observatorio del Roque de los Muchachos of the Instituto de Astrofíca de Canarias and the 3m-Shane Telescope in Lick Observatory. All IPHAS data are processed by the Cambridge Astronomical Survey Unit, at the Institute of Astronomy in Cambridge. This work is based on observations made with the Spitzer Space Telescope, which is operated by the Jet Propulsion Laboratory (JPL), California Institute of Technology, under NASA contract 1407. We have made use of the SIMBAD database operated at CDS, Strasbourg, France, and the Two Micron All Sky Survey. This project has also been supported by MEC, through grant AyA2007-67458.

References

[1] Allen, P. R., Luhman, K. L., Myers, P. C., et al. 2007, ApJ, 655, 1095

[2] Baraffe, I., Chabrier, G., Allard, F., & Hauschildt, P. H. 1998, A&A, 337, 403

[3] Barrado y Navascués, D., & Martín, E. L. 2003, AJ, 126, 2997

[4] Bouy, H., Huélamo, N., Martín, E. L., et al. 2007, A&A, 463, 641

[5] Carpenter, J. M., Mamajek, E. E., Hillenbrand, L. A., & Meyer, M. R. 2006, ApJl, 651, L49

[6] Dahm, S. E., & Carpenter, J. M. 2009, AJ, 137, 4024

[7] D'Alessio, P., Calvet, N., Hartmann, L., Lizano, S., & Cantó, J. 1999, ApJ, 527, 893

[8] Drew, J. E., Greimel, R., Irwin, M. J., et al. 2005, MNRAS, 362, 753

[9] Fazio, G. G., Hora, J. L., Allen, L. E., et al. 2004, ApJS, 154, 10

[10] Furlan, E., Watson, D. M., McClure, M. K., et al. 2009, ApJ, 703, 1964

[11] González-Solares, E. A., Walton, N. A., Greimel, R., et al. 2008, MNRAS, 388, 89

[12] Guieu, S., Dougados, C., Monin, J.-L., Magnier, E., & Martín, E. L. 2006, A&A, 446, 485

[13] Hernández, J., Hartmann, L., Megeath, T., et al. 2007, ApJ, 662, 1067

[14] Jayawardhana, R., Mohanty, S., & Basri, G. 2002, ApJl, 578, L141

[15] Lada, C. J., Muench, A. A., Luhman, K. L., et al. 2006, AJ, 131, 1574

[16] Martín, E. L., Dougados, C., Magnier, E., et al. 2001, ApJl, 561, L195

[17] Rieke, G. H., Young, E. T., Engelbracht, C. W., et al. 2004, ApJS, 154, 25

[18] Scholz, A., Jayawardhana, R., Wood, K., et al. 2007, ApJ, 660, 1517

[19] Sicilia-Aguilar, A., Hartmann, L., Calvet, N., et al. 2006, ApJ, 638, 897

[20] Skrutskie, M. F., Cutri, R. M., Stiening, R., et al. 2006, AJ, 131, 1163

[21] Valdivielso, L., Martín, E. L., Bouy, H., et al. 2009, A&A, 497, 973

[22] Whitney, B. A., Wood, K., Bjorkman, J. E., & Cohen, M. 2003, ApJ, 598, 1079