Revista Mexicana de Astronomía y Astrofísica
Universidad Nacional Autónoma de México
rmaa@astroscu.unam.mx
ISSN (Versión impresa): 0185-1101
MÉXICO

2006
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Revista Mexicana de Astronomía y Astrofísica, volumen 026
Universidad Nacional Autónoma de México
Distrito Federal, México
pp. 37-38

RevMexAA (Serie de Conferencias), **26**, 37–38 (2006)

BROWN DWARF AND VERY LOW MASS STARS SEARCH IN ORION OB1A AND OB1B ASOCIATIONS

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RESUMEN

Se presentan los resultados iniciales de la primera búsqueda óptica e infrarroja a gran escala de enanas marrones en la región de formación estelar de Orión. Las observaciones ópticas fueron hechas con el telescopio Schmidt Jürgen Stock y la cámara QUEST-1 del Observatorio Astronómico Nacional de Venezuela y cubren un área de 180 $grad^2$ de los cuales $\approx 32 grad^2$, que incluyen una porción de la subregión OB1a y la casi totalidad de OB1b, se estudian en este trabajo. Las observaciones en las bandas R e I fueron procesadas mediante una técnica de suma de imágenes incrementando las magnitudes límite a I = 20.5 y R = 21.5 con completitud hasta I = 19.0 y R = 20.0. La fotometría infrarroja en las bandas J, H and K se obtuvo de la base de datos del sondeo Two Micron All Sky Survey. Observaciones espectroscópicas de una primera muestra de candidatas, realizadas con HECTOSPEC, permitieron la confirmación de 15 estrellas de muy baja masa y 9 enanas marrones.

ABSTRACT

The initial results of the first large-scale optical-infrared search for brown dwarfs in the Orion star forming region are presented. Optical observations were performed with the Jürgen Stock Schmidt telescope and the QUEST-1 camera at the National Astronomical Observatory of Venezuela, covering an area of 180 deg^2 of which $\approx 32deg^2$, that include a portion of OB1a and most of OB1b sub-associations, are studied in this work. R and I band observations were processed with a coadding technique, increasing the limit magnitude to I = 20.5 and R = 21.5 with completitude to I = 19.0 and R = 20.0. Infrared photometry in J, H and K bands was obtained from the Two Micron All Sky Survey data base. Spectroscopic observations of a first sample of candidates was performed with HECTOSPEC and allowed the confirmation of 15 and 9 bonna fide very low mass stars and brown dwarfs respectively.

Key Words: **STARS: FORMATION — STARS: LOW MASS, BROWN DWARFS**

1. INTRODUCTION

During the last years important efforts in the research of young substellar objects have been developed in order to stablish observationally the initial mass function in the substellar domain, as well as the nature of the brown dwarf (BD) formation process. Star forming regions (SFR) and young stellar clusters, unlike stars of the solar neighborhood, allow the interpretation of the observational data without evolutionary or dynamical biases, because their ages and distances are better known. On the other hand, the distance, angular extention and the strong and inhomogeneus extintion are important limitations in the observation of these regions. Here we summarize the initial results of the first large-scale optical-infrared search for BD in the Orion SFR, based on optical observations of $\approx 32deg^2$, covering a portion of the OB1a and most of the OB1b sub-associations.

2. OPTICAL OBSERVATIONS

Since 1998 a multi-band and multi-epoch large-scale survey ($\approx 180deg^2$) of the Orion SFR is being performed with the Jürgen Stock 1.0/1.5 Schmidt telescope and QUEST-1 camera, at the National Astronomical Observatory of Venezuela. The camera was developed by the QUEST colaboration (Snyder et al. 1998) and is composed of 16 ccds, of 2048 × 2048 pixels each, in a 4 × 4 array providing a field of view of $5.4deg^2$ and yielding a scale of ≈ 1.02 $arcsec/pix$. For observations in the range $-6^o < \delta < 6^o$ the system works on drift-scan mode producing quasi-simultaneous observations in four different filters at a rate of ≈ 34.5 $deg^2/hour/filter$ with a limit magnitud $I_{lim} = 19.5$. According to the Baraffe et al. (1998) models, the substellar limit at solar metallicity ($0.072M_\odot$) is placed at $I \approx 19.6$ in the Orion SFR, assuming an extintion $A_V = 4$. This suggested the usage of a coadding technique in

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order to increase the limit and completitude magnitudes. Adding 8 single scans we obtain a gain of ≈ 1 magnitude. The details of the coadding technique on drift scan observations, image processing, detection of point sources, aperture photometry, calibrations and astrometry are explained in Downes et al. 2006 (in preparation). The resulting coadded scan covers the region $75^o < \alpha < 87^o$, $-2.2^o < \delta < 0.1^o$ in R and I filters, with $R_{lim} = 21.5$, $I_{lim} = 20.5$ limit magnitudes and completitude to $R_{com} = 20$, $I_{com} = 19$ with saturation at $R_{sat} \approx I_{sat} \approx 13$. Finally, $\approx$ 160000 objects were also identified in the 2MASS [3] data base.

3. CANDIDATE SELECTION

The candidate selection was performed based on positions in color-magnitude and color-color diagrams. A first selection was performed in I vs I-J and H vs. I-K diagrams in which we select objects placed above the isochrone that can be accepted as an age upper limit of each region (12.6 Myr for OB1a and 6.3 Myr for OB1b; Briceño et al. 2005) and under the 0.3 $M_\odot$ evolutionary track from Baraffe et al. (1998). Finally, the selected objects were ploted in I-K vs J-H diagrams in which only objects placed above the M5 redenning vector were selected as candidates. The final catalogue contains 46 candidates in OB1a and 641 in OB1b.

4. SPECTRAL CLASSIFICATION

Due to the expected contamination of M stars, spectroscopic observations are needed to distinguish young late-type pre-main sequence objects. A first sample composed by 4 candidates from OB1a and 26 from OB1b, was spectroscopically observed during December 2004, and March and April 2005 using the HECTOSPEC multifiber spectrograph (Fabricant et al. 1998) with a $6.2\mathring{A}$ spectral resolution and a wavelength coverage from 3700 to 9150 $\mathring{A}$. Spectral clasification was performed by comparison, with standard spectra, of 16 spectral molecular features in the range between $4775 - 8880$ $\mathring{A}$ that include substellar features such as TiO and VO bands, following the scheme of Hernández et al. (2004).

5. MEMBERSHIP

According to the Baraffe et al. (1998) models, objects in the substellar limit and with Orion SFR

[3]This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

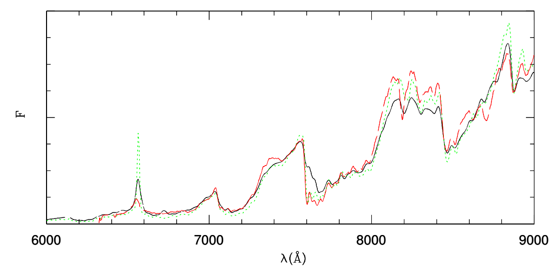

Fig. 1. Spectra of an M8 SFR member (solid), superimposed with library spectra of a young M8 dwarf (dotted) and an M8 field star (dashed). All spectra were normalized and shows that the NaI ($8200\mathring{A}$) absorption feature of the candidate, corresponds to a low surface gravity young object.

ages have temperatures of $\approx 2990K$, which corresponds to M6 spectral type (Luhman, 1999). However, candidates later than M6 can be BD population from the SFR, background giant stars or Md stars from the foreground. Thus, we consider as bonna fide BD, objects later than M6 that belong to the SFR. Their membership was justified based on the presence of $H\alpha$ emission, which is a common feature in young objects, and NaI absorption which is weaker than for M field dwarfs because pre-main secuence objects are still contracting. Finally we have 15 very low mass stars (VLMS) and 9 BD members of the SFR, 3 Md from the field and 3 reddened objects early than K8.

Figure 1 shows one of the candidates clasified as a region M8 member.

6. CONCLUSIONS

We present the analysis of $\approx 30deg^2$ of the first large-scale (180 deg^2) optical survey for the detection of BD and VLMS in the Orion SFR which, with data from 2MASS, allowed the selection of 46 candidates in OB1a and 641 candidates in OB1b. The spectroscopic observations of a first sample of candidates allowed the confirmation of 24 M objects of the SFR, of which 9 are later than M6 and can be considered as bonna fide BD (Downes et al. 2006 in preparation). The purity of the candidate sample shows the usefullness of optical data in BD and VLMS candidate selection showing the potential of our survey.

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