RevMexAA (Serie de Conferencias), **46**, 99–100 (2015)

STAR FORMATION IN THE LEADING ARM OF THE MAGELLANIC STREAM

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RESUMEN

Las Nubes de Magallanes son el ejemplo más cercano de un par de galaxias en interacción. La dinámica de dicho proceso ha generado las estructuras gaseosas conocidas como la Corriente de Magallanes, el puente entre las Nubes y el Brazo Delantero (BD), una estructura irregular que precede a las nubes en su órbita. El BD debe tener un origen de marea gravitatoria, sin embargo se requiere de la interacción hidrodinámica del mismo con el halo gaseoso caliente de la Galaxia para reproducir la morfología y cinemática del hidrógeno neutro que lo compone. Acá demostramos por primera vez que existen estrellas jóvenes recién formadas en el BD, lo que indica que la interacción entre las Nubes y la Galaxia es capaz de iniciar eventos de formación estelar en ciertas regiones del BD en las afueras del disco galáctico, muy lejos de las Nubes y del puente de Magallanes.

ABSTRACT

The Magellanic Clouds are the nearest example of a pair of interacting galaxies. The dynamics of their interaction has created the gaseous structures known as the Magellanic Stream trailing the pair's orbit about the Galaxy, the bridge between the Clouds, and the leading arm (LA), a wide and irregular feature leading the orbit. The LA must have a tidal origin, but a hydrodynamical interaction with the gaseous hot halo and disk of the Galaxy is required to reproduce its morphology and kinematics, as seen in neutral hydrogen (HI) observations. Here we show for the first time that young, recently formed stars exist in the LA, indicating that the interaction between the Clouds and our Galaxy is strong enough to trigger star formation in certain regions of the LA, in the outskirts of the MW disk, far away from the Clouds and the bridge.

Key Words: Magellanic Clouds — proper motions — stars: formation

1. INTRODUCTION

In a recent study, Casetti-Dinescu et al. (2012) listed 567 OB-type star candidates in a ∼7900 deg^2 area encompassing the Magellanic system. The photometric and proper-motion selection was aimed at finding hot (earlier than B5) distant stars with motions consistent with membership in the Magellanic system. In the LA region, three stellar overdensities were found comprising a total of 45 candidates of which 42 have been observed spectroscopically by us. Their spatial distribution is shown in Figure 1, as well as the HI distribution from the GASS survey (McClure-Griffiths et al. 2009; Kalberla et al. 2010) for 150 km s^{-1} $\leq RV_{LSR} \leq$ 400 km s^{-1}. We label the three candidate overdensities as A at $(\Lambda_M, B_M) \sim (15°, -22°)$, B at $(\Lambda_M, B_M) \sim (42°, -8°)$ and C at $(\Lambda_M, B_M) \sim (52°, 28°)$, as seen on the sky in Magellanic coordinates.

2. OBSERVATIONS

Intermediate-resolution (1.3 Å) spectra in the range 3650 to 5230 Å, were obtained with the IMACS spectrograph on the 6.5 m Baade telescope at Las Campanas Observatory. The resulting signal-to-noise ratio of the spectra was higher than 50 for all the targets. Cross-correlation techniques were used to measure heliocentric radial velocities (RV). In absence of a prior knowledge of the temperature and gravity of the targets, the synthetic spectrum of a main-sequence B-type star was adopted as a template. The final uncertainty is estimated to be typically 5 km s^{-1}. Temperature, gravity, surface helium abundance, and, in some cases, rotational velocity, were also derived, using standard routines.

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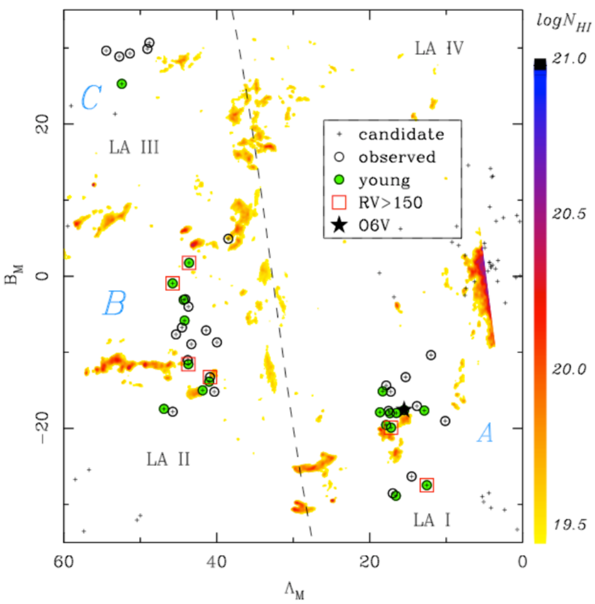

Fig. 1. Sky distribution of our OB candidates. The LA branches, I to IV, are indicated (Venzmer et al. 2012). Spectroscopically observed stars are shown with circles. Filled green symbols are young stars. Symbols highlighted with red squares are stars with $RV > 150$ km s^{-1}. The dashed line represents the Galactic plane.

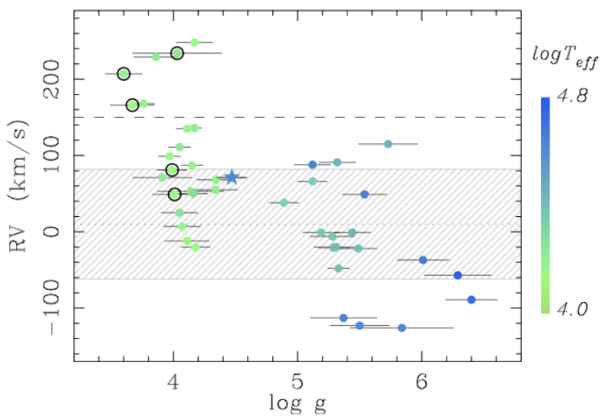

Fig. 2. RV vs. $\log g$, color-coded by $T_{\rm eff}$. The mean $RV \pm 2\sigma$ for the Galactic thin+thick disk (Robin et al. 2003) is indicated with a hatched area. The dashed line at 150 km s^{-1} shows the lower limit for LA RV-member candidates. From the group of six stars with $RV > 150$ km s^{-1}, only one is classified as an sdB, primarily on account of its low He abundance. Fast rotators ($v \sin i >$ 100 km s^{-1}), common among early-type main-sequence stars, but not among sdBs (Geier & Heber 2012), are highlighted in black circles. The star symbol indicates the very distant massive young O6V star.

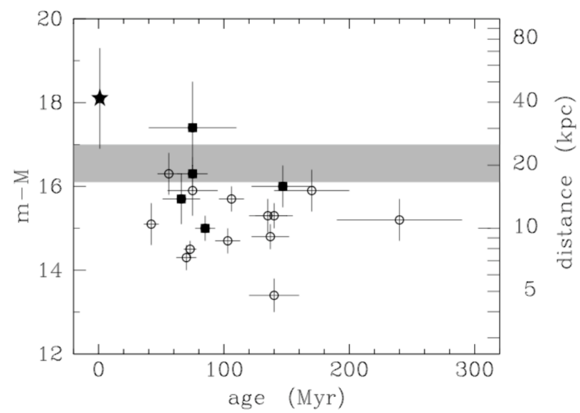

Fig. 3. Distance moduli *vs.* ages for our 19 massive young stars. Those with $RV > 150$ km s^{-1} are shown with filled squares. The gray band represents the kinematical distance (± 20% error) of one high velocity cloud member of the LA (McClure-Griffiths et al. 2008). The star symbol indicates the very distant massive young O6V star. The most distant HI structure associated with the MW disk is a spiral arm at R=18−24 kpc (McClure-Griffiths et al. 2009), while the stellar edge of the disk has R∼14 kpc e.g., (Minniti et al. 2011).

3. RESULTS AND CONCLUSIONS

We found 19 young massive stars, 22 foreground B subdwarfs (sdB) or white dwarf stars and 1 uncertain object. Five of the young massive candidates have $RV > 150$ km s^{-1} (see Figure 2), which makes them probable LA members. Absolute magnitudes and ages were derived for all the young stars based on isochrones in the $\log g - T_{\rm eff}$ plane (Bressan et al. 2012) (See Figure 3). We found a candidate (star symbol in all figures) to be a very hot spectral-type O6V and thus massive ($\sim 40 M_\odot$), short-lived (12 Myr) and very distant (∼ 40 kpc from us) star, that most probably was born in situ.

Our observations establish that conditions were met for recent star formation in the LA material, which interacted with the gaseous component of the Galactic disk present at the outskirts of it.

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