STELLAR MAGNETIC ACTIVITY IN THE ORION STAR FORMATION COMPLEX

Batista, M. G.[1,2], Pinzón G.[1], Hernández, J [3].

[1] Universidad Nacional de Colombia, (mbatista@unal.edu.co),(gapinzone@unal.edu.co)
[2] Universidad de los Andes, Bogotá, Colombia
[3] Instituto de Astronomía, Universidad Autónoma de México, Ensenada, Baja California

INTRODUCTION

The impact of the magnetic activity during the earliest stages of the formation of stars is an important open issue still not understood. A very precise characterization of this parameter is required due to magnetic phenomena play an important role in the formation and early evolution of stars and planets. In this work, we present the approach for measuring magnetic activity indicators in stars belonging to the Orion Star Forming Complex, located at ~400 parsec and with stellar populations with an age range of ~1-10 Myr. We conducted a preliminary analysis of HECTOSPEC spectra obtained for 1780 stars belonging to this star forming region.

THE SAMPLE

The Orion star formation complex consists mainly of 2 OB star associations which house young stellar populations in different evolutionary states. The OB λOri star association is characterized by a gas and dust ring of ~ 20 radio parsec (hernandez 2009, hernandez 2010). Toward the south of this ring is located the star association Orion OB1 (Briceno 2018) which is made up of very young groups (1-2 Myr), still embedded in the primeval cloud (eg, ONC), groups that are dispersing their primitive cloud (σ Ori, 3-5 Myr Ori OB1b) and groups that have mostly dispersed their source material (Ori OB1a, 25 Ori, 7-10 Myr).

Recently, a sample of more than 2000 young low-mass stars (<1.5 solar masses; henceforth T Tauri stars) has been reported in the Orion OB1 star association, confirmed by the presence of lithium in absorption or because they exhibit strong emission in Hα product of accretion processes (Briceno 2018). This sample of T Tauri stars represents just over 20% of our database, which has more than 9,700 stars distributed across 35 observation fields within the Orion OB1 region (Figure 1). An important fraction of this T Tauris sample have spectra obtained with the HECTOSPEC spectrograph (resolution ~ 10000), which contain ionized calcium lines (Ca II; lines H and K, located at 3968.47 and 3933.68 Å, and the infrared triplet in 8498, 8542 and 8669 Å respectively), which are used as stellar activity tracers [Ref].

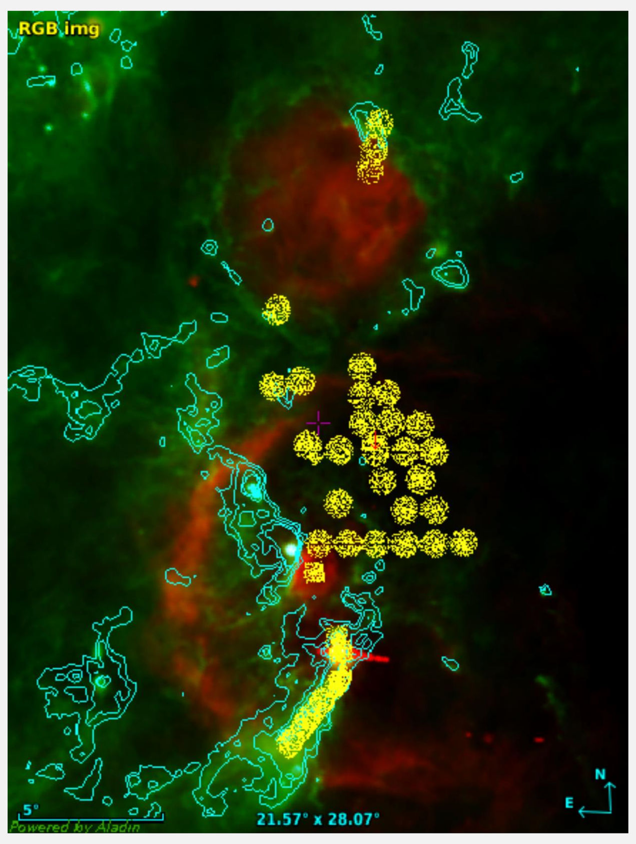

Figure 1: Complejo de Formación Estelar de Orión. La emission en Hα y la emisión del polvo se muestra en color rojo y verde respectivamente. Los isocontornos color cyan revelan las zonas de emisión de monóxido de carbono (CO; J 1>0). Los 35 campos de Hectospec se muestran con puntos amarillos.

CaII H-K and IRT lines as Activity Tracers

Considering that the atmosphere of a star is in radiative equilibrium, the external flux emitted by the plasma should be constant. This is true for some stars (Auer & Mihalas 1969; Skumanich 1970), but in many cases the prominent emission in the center of the Fraunhofer lines, such as H & K of Ca II, are clear signs of the deviation of the radiative equilibrium. It is known that magnetic activity in solar-type stars decreases over time (Skumanich 1972, Baliunas et al. 1995 and Wright et al 2004), which suggests that young stars must be very active and have high rotation rates.

The material that forms the stellar chromosphere is heated by magnetohydrodynamic processes at temperatures below ~ 20,000 K (Schrijver & Zwaan 2000), producing emission lines in the optical and ultraviolet ranges of the spectrum. In order to establish a range of log g and temperature to study in the stellar sample of this work, the MIST and PARSEC models were used, for stars with masses less than 5 MΘ and ages between 0.1 Myr and 100 Myr. The result of these simulations is in figure 2.

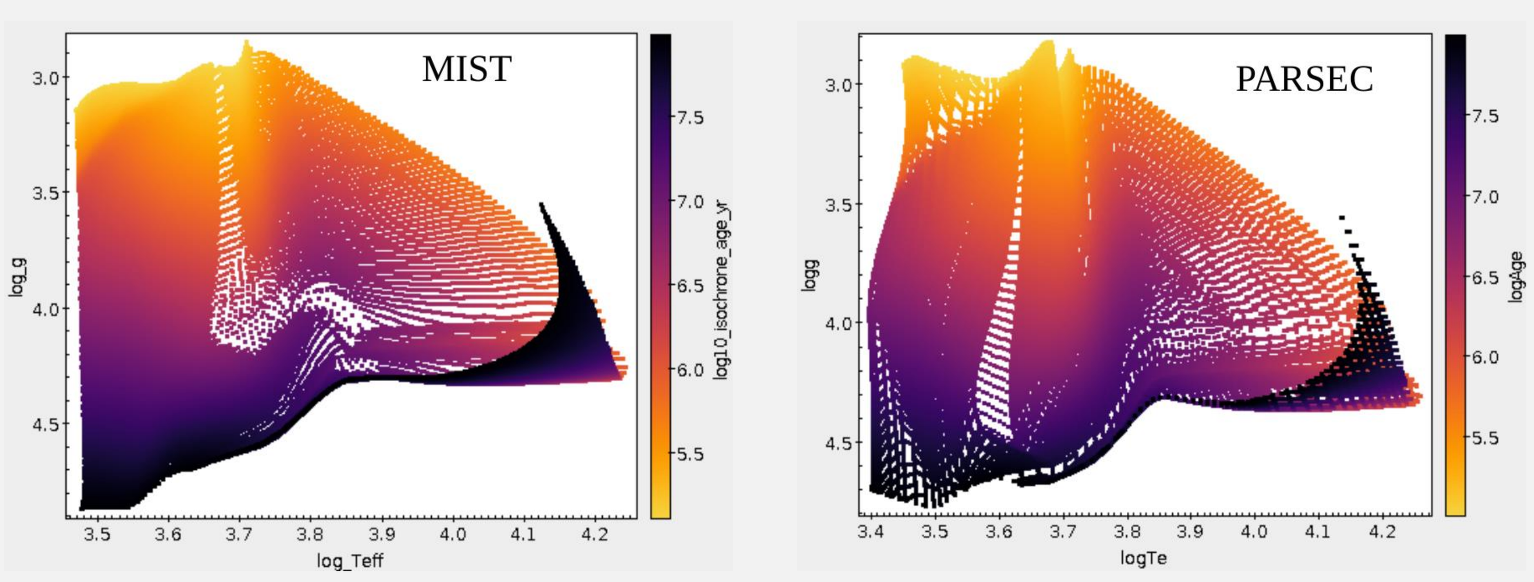

Figure 2: Results of the variation of log g with the temperature for stars with ages between 0.1 Mys and 100 Mys and masses less than 5 MΘ, using the MIST and PARSEC models respectively.

The stars to consider will basically have log g between 3 to 5. Also stars with temperatures below 16000K, basically B5 or earlier stars, which guarantees that we have stars that due to their convective nature can generate magnetic activity (eg late F, G , K and M, regime of TTS and IMTTS).

An example of the spectra obtained with HECTOSPEC is found in Figure 3, where the emission and absorption lines of H & K and IRT of Ca II can be seen. These spectra have yet to be normalized and the photospheric contribution must be eliminated in order to have the true chromospheric emission. The photospheric flow will be estimated from stellar models, applied to the different spectral types that we find in the sample. The spectra of these models will be degraded until a resolution similar to that of the spectrograph is obtained.

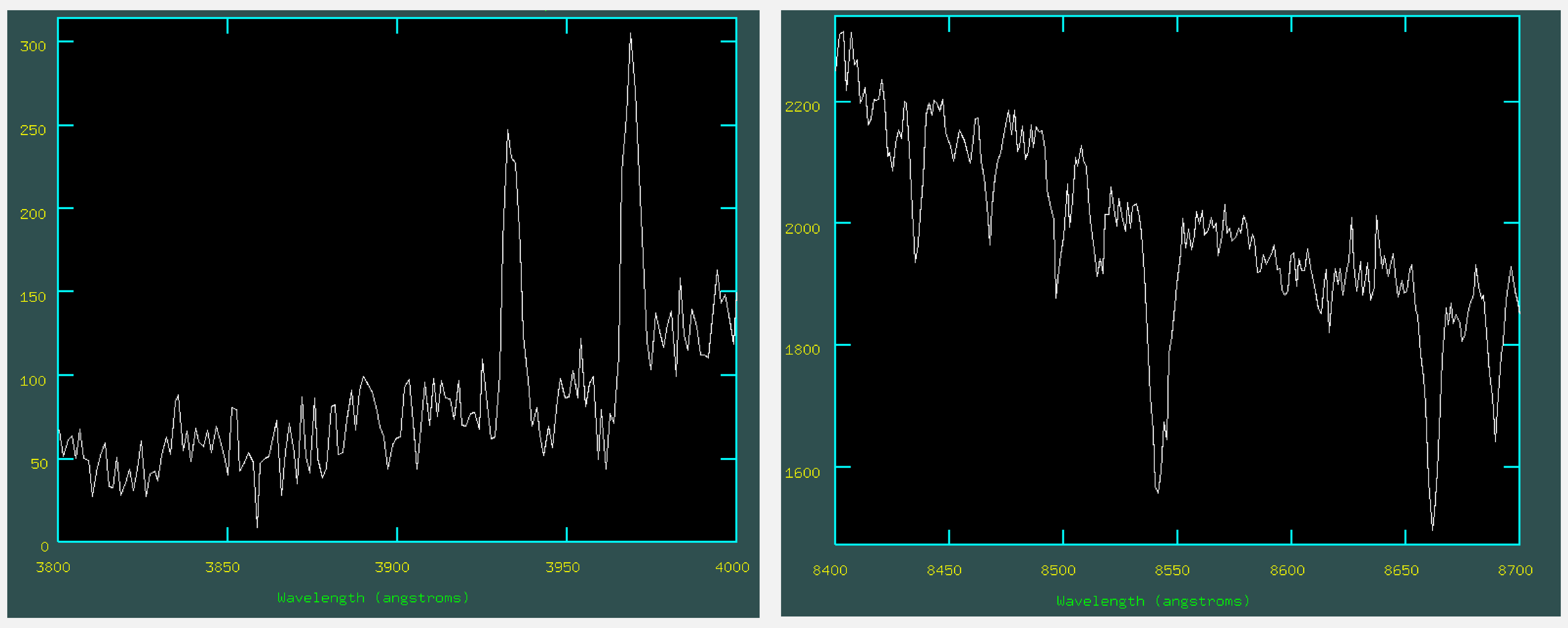

Figure 3: Spectra of an observated star from the sample, with the HECTOSPEC spectrograph. The left spectrum shows the emission lines of H & K of Ca II. The spectrum on the right evidence the absortion lines of the infrared triplet (IRT) of Ca II. This group of features will be crucial to estimate the activity in this young stars sample.

Currently, the measures have been performed with the stars observed in one of the 35 fields of λ Ori. The identification of the Tauri T stars of this field was made by comparison with the Briceño et al 2018 catalog. The comparison of the equivalent widths of the K (3933.68 Å) and IRT II (8542 Å) lines of Ca II with respect to the surface temperature of the star, it can be seen in figure 4. In both cases, the T Tauri stars fall below the field and have less dispersion for temperatures below 5000 K. After ~ 7000 K the equivalent width of the activity tracers seem to decrease, but it is believed to be a consequence of the mixture with nearby lines that manifest themselves for very high temperatures.

One of the main drawbacks has been the normalization of the synthetic spectra in the area of the H & K lines, especially for stars with surface temperatures below 3000 K. Tests will be made with different methods of estimation of equivalent width, and with different models synthetic before estimating the chromospheric flow of activity tracers.

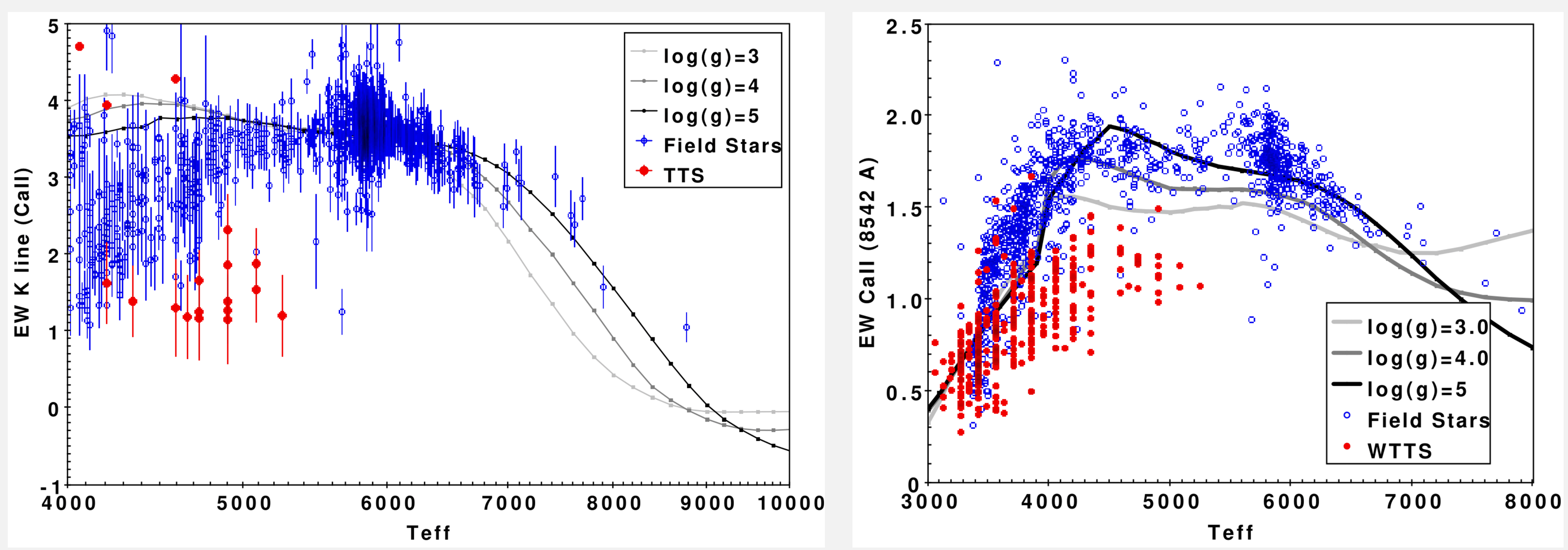

Figure 4: Estimation of the equivalent width of the K and IRT II lines (8542 Å) with respect to the surface temperature. Field stars are presented with blue circles. The stars identified as T Tauris, according to the catalog of Briceño et al 2018, appear as red dots. Solid gray-scale lines represent trends in equivalent widths expected for stars with log g between 3 and 5.

The main objective of this research is to be able to study in detail the activity in young stars identified as T Tauri in the observed fields of the Orion star formation complex and its relationship with the presence of protoplanetary discs in accretion, Lithium depletion and radio inflation stellar.

Thereafter, try to find the connection between the protoplanetary disk, activity, stellar rotation and lithium wear observed in the stellar surface, that by now is not well known. Finally, from the observables of stellar rotation we can infer the inclination of the rotation pole and perform statistical studies related to the distribution of star pole inclinations in young stellar populations.

References

[1] A. Hempelmann, M. Mittag, J. N. Gonzalez-Perez, J. H. M. M. Schmitt, K. P. Schröder, and G. Rauw. Measuring rotation periods of solar-like stars using TIGRE. A study of periodic CaII H+K S-index variability., 586:A14, February 2016.

[2] C. Briceno, N. Calvet, J. Hernandez, A. K. Vivas, C. Mateu, J. J. Downes, J. Loerincs, A. Perez-Blanco, P. Berlind, C. Espaillat, L. Allen, L. Hartmann, M. Mateo, and J. Bailey, III. The CIDA Variability Survey of Orion OB1 II: demographics of the young, low-mass stellar populations. arXiv e-prints, May 2018.

[3] J. Bouvier. Observational studies of stellar rotation. In P. Hennebelle and C. Charbonnel, editors, EAS Publications Series, volume 62 of EAS. Publications Series, pages 143{168, September 2013.

[4] J. Hernandez, N. Calvet, L. Hartmann, J. Muzerolle, R. Gutermuth, and J. Stauffer. Spitzer Observations of the λ Orionis Cluster. I. The Frequency of Young Debris Disks at 5 Myr. , 707:705{715, December 2009.

[5] R. M. Cutri and et al. VizieR Online Data Catalog: AllWISE Data Release (Cutri+ 2013). VizieR Online Data Catalog, 2328, November 2013.

[6] S. Kenyon., L. Hartmann. Pre-main sequence evolution in the Taurus-Auriga molecular cloud. 101, November 1995.