Identification of CTTS in IC348 using IRAC/Spitzer and LAMOST.

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Resumen

This study focuses on the identification of T Tauri stars in the IC348 region using data from the Spitzer IRSA space telescope. FITS files of the region were accessed in several channels (3.6, 4.5, 5.8, 8.0) and a custom code was applied to perform photometry, obtaining the luminosity magnitudes in each channel. Spectroscopy analyses were carried out to determine the equivalent widths of the objects identified by photometry. Those with negative equivalent widths (indicative of emission) were selected as candidates for T Tauri stars in the IC348 region. Only 2 subregions of IC348(N and S) were studied, 18 T Tauri star candidates were found in the first one, while no candidates were found in the second one.

1. Introduction

1.1. Classical T Tauri Stars

Classical T Tauri stars are low-mass stars in their early stages of evolution. Their name comes from the prototype star T Tauri, located in the constellation Taurus. These stars are at a crucial stage of their evolution, characterized by dense circumstellar disks of gas and dust, known as protoplanetary disks or accretion disks, which is made up of substances that envelop the star as it forms, fostering the conditions necessary for planet formation.

Accretion processes occur within this disk as the surrounding material is progressively drawn to the growing star by gravity. Which is why T Tauri stars are identified by several distinctive features such as the excess of infrared radiation. Due to the presence of the protoplanetary disk, these stars emit significant amounts of radiation in the infrared spectrum. In addition, T Tauri show high levels of X-ray emission, resulting from the interaction between the young star and its circumstellar environment.

Understanding how this accretion process works requires an understanding of the magnetospheric accretion model. According to this model, material from the disk is channeled to the stellar surface via field lines created by the interaction between the star's magnetic field and the disk. This process, represented in figure 1, affects the disk's evolution as well as accelerating the star's growth.

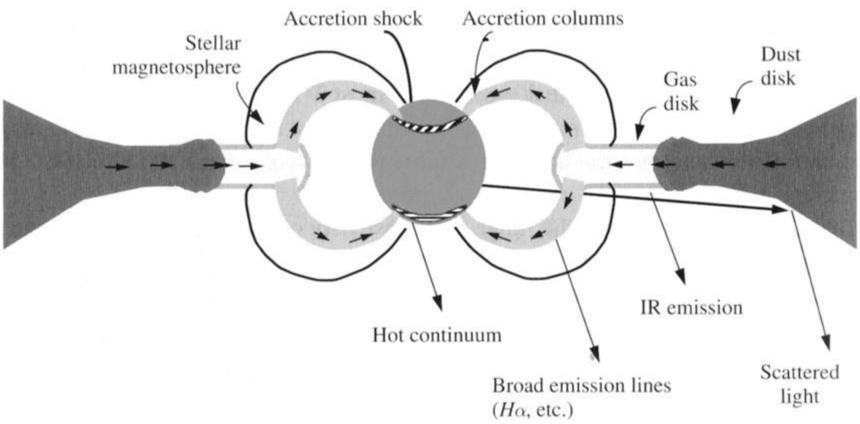

Figura 1: Model of disk accretion in CTTS [3].

T Tauri star research greatly advances our understanding of the constantly evolving cosmos by shedding insights on the genesis and evolution of planetary systems as well as star formation processes. However, the identification of T Tauri stars represent a crucial challenge in understanding stellar evolution and planetary system formation. In this study, a comprehensive methodology based on data from the Spitzer IRSA space telescope was used to identify these stars in the IC348 region.

1.2. IC348 Region

The IC348 region has become a focal point for astronomical research due to its star formation dynamics. This region is located at an estimated distance of about 1000 light-years from Earth in the Perseo constellation.

The IC348 region is particularly attractive for the study of T Tauri stars because IC348 is known to be an active stellar nursery as several young star clusters and groups of forming stars are observed. These clusters contain roughly 400 stars, within an angular diameter of 20”, estimated to be between 0.5 and 2 million years old. In addition, its relative proximity to Earth provides an exceptional opportunity for detailed observation and characterization of these young stellar objects.

We selected 2 subregions present in IC348 for the study. The subregions selected can be seen in the image above.

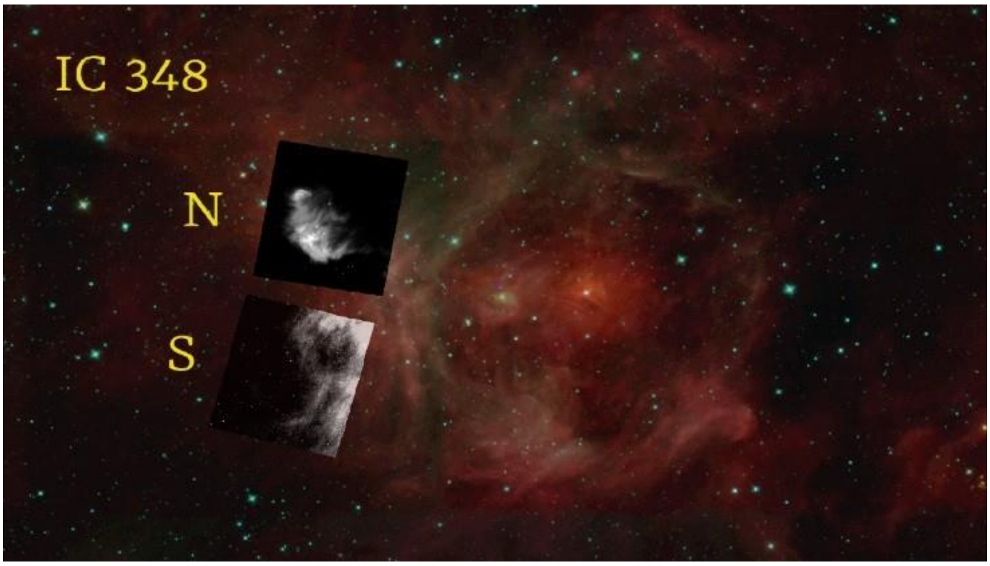

Figura 2: Star-forming region IC348 with the 2 subregions highlighted. Obtained from [2].

2. Methodology

The process began with the acquisition of FITS files of the region in the 3.6, 4.5, 5.8 and 8.0 micrometer channels of the infrared spectrum using Spitzer IRSA. Subsequently, we use SAO Image in order to obtain a catalog retrieved from GAIA EDR3 survey, matching the objects in the FITS files using radius of 16 arcmin. Furthermore, a base code provided by project supervisor Giovanni Pinzon, was customized and enhanced to perform specific photometric analyses in this region. We used only the objects that were found in all 4 channels as a result of the photometry. We selected only the objects with a magnitude error below 20 %.

At this point, we filtered the objects obtained by selecting only the objects with a [3.6]Mag below 15, as it is considered that those with a magnitude above 15 can represent a case of extragalactic contamination. Afterwards, a spectroscopy analysis was applied to obtain the equivalent widths of the objects identified by the photometry. For this purpose, we used LAMOST survey data releases in order to obtain FITS files containing the information required for the code (also a personalized code from a base code provided by the supervisor).

Finally, for the final selection of T Tauri star candidates, we selected the objects that posses a negative equivalent width in the spectra, as this is an indicative of emission, and are inside the class II region in a color-color diagram.

3. Results

Graphs 3 and 4 represent the first filter performed for IC348N and IC348S respectively, where the black objects are the objects to be followed and the gray objects are the objects to be excluded as they are considered extragalactic contamination.

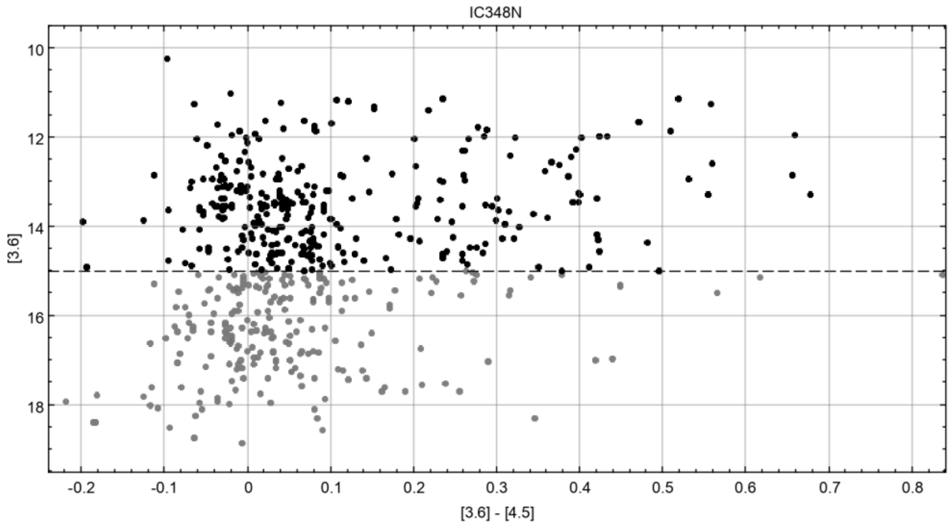

Figura 3: Visualization of the first filter applied to the data of IC348N. [3.6] Mag <15.

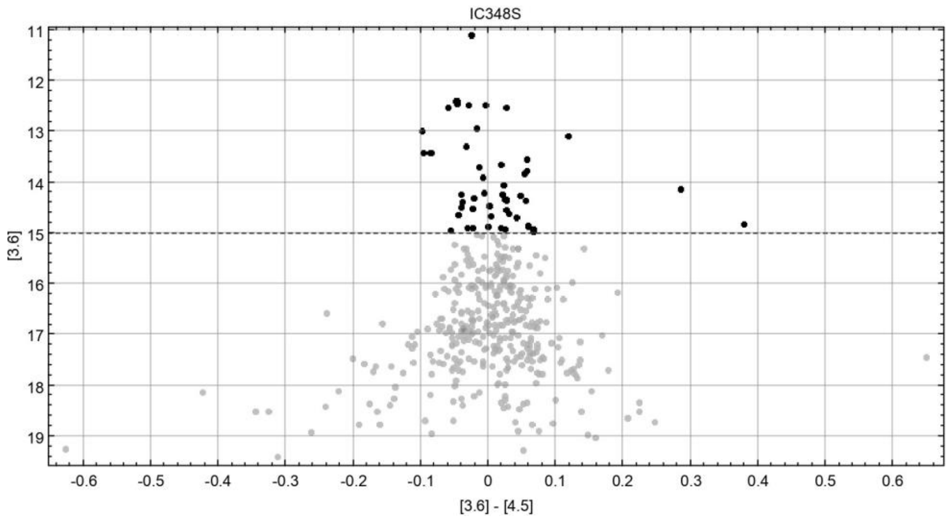

Figura 4: Visualization of the first filter applied to the data of IC348S. [3.6] Mag <15.

Graphs 5 and 6 represent the distribution of all of the objects in the region in a color-color diagram for IC348N and IC348S respectively.

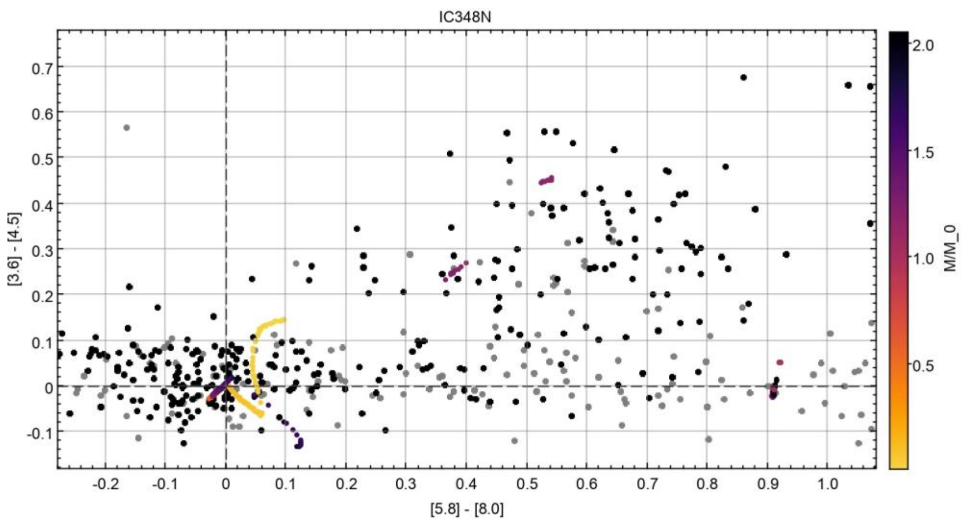

Figura 5: Color-color diagram containing all the objects obtained for IC348N.

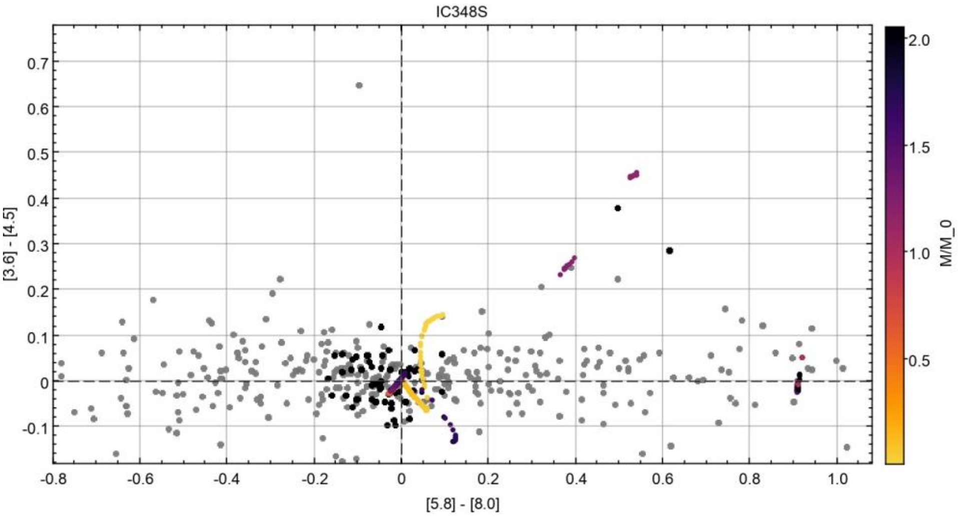

Figura 6: Color-color diagram containing all the objects obtained for IC348S.

Finally, graphs 7 and 8 represent the spectroscopy results for IC348N and IC348S respectively.

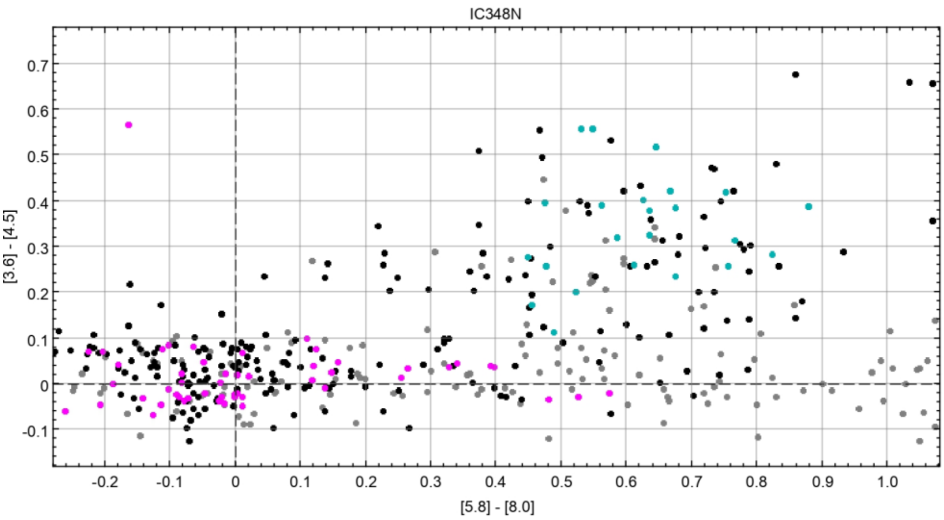

Figura 7: Color-color diagram containing all the objects obtained for IC348N. Pink and blue objects represent all the objects that are in emission (negative equivalent width). Blue ones are a specific selection out of the ones in emission that are inside the Class II classifcation in a color-color diagram.

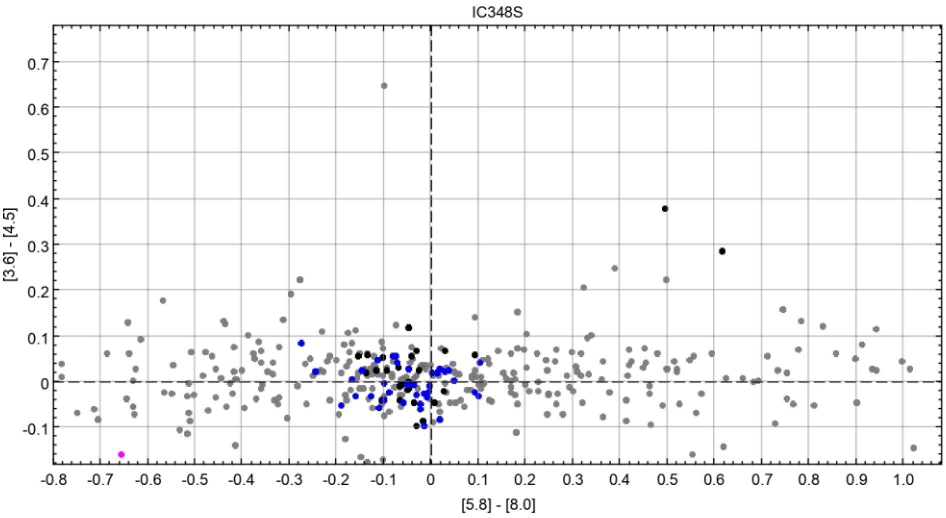

Figura 8: Color-color diagram containing all the objects obtained for IC348S. Dark blue objects represent the objects that are in absorption. Pink objects represent those in emission.

4. Discussion

In graph 7, objects in color represent all objects that possessed a negative equivalent width (83 objects in emission). No objects in absorption (positive equivalent width) are highlighted, however, 35 objects in absorption were found. The blue objects are a specific selection from the objects in emission that are inside the class II region of a color-color diagram, those 22 objects were found as candidates for T Tauri stars in the IC348N region.

On the other hand, for graph 8, both objects in emission and absorption are highlighted in colors. Dark blue represent the objects in absorption (37 objects), while pink represent the objects in emission. It can be seen that only one object appears in emission, however, it is not inside the class II region. That is why we conclude that no candidates for T Tauri stars were found for IC348S.

We now present the table containing our candidates for T Tauri star in star-forming region IC348. All of them located in IC348N.

Source	RA_ICRS	DE_ICRS	Gmag	BPmag	RPmag	BP-RP	1_mag_o	2_mag_o	3_mag_o	4_mag_o	EW_HA
216674674813091072	56.06599564718	31.99351988552	18.187578	20.7916	16.706821	4.084778	15.035029	14.725063	14.374582	13.66827	-35.49003920425311
216674816547870464	56.11877944784	31.99831531545	15.782004	17.647942	14.268335	3.379606	13.083054	12.857284	12.549079	12.144641	-7.171515626248244
216675125785515136	56.12419379188	32.01513289952	18.234203	20.845087	16.653078	4.192009	14.273657	13.894479	13.420217	12.834379	-51.80214675721912
216676775052953216	56.15824530724	32.05822285362	15.097547	16.500845	13.914116	2.586729	12.26937	11.932708	11.548826	10.775827	-14.191777257849767
216676981211381632	56.18631278667	32.06733542258	14.686735	16.39437	13.416403	2.977966	11.542868	10.932868	10.510624	10.011867	-29.5870084954336
216678321241170304	56.16059684231	32.13348993869	15.662874	17.546856	14.36929	3.177566	12.556992	12.109484	11.895268	11.47065	-16.946953160229945
216678389960646400	56.13574922489	32.14881031926	15.857361	17.928017	14.483672	3.444345	13.114722	12.950537	12.751878	12.312575	-7.458863535717054
216678493039859328	56.15588359308	32.15022677868	16.421408	18.170822	15.080473	3.090349	12.71749	12.275871	11.740396	10.911315	-2.9182742880332277
216678660542082560	55.98348942867	32.03699395193	16.965364	19.13158	15.530375	3.601206	11.402769	10.83165	10.256297	9.6604029	-40.72141283243263
216679382096866944	55.99952731092	32.078149449	18.375765	20.830177	16.868113	3.962065	14.982535	14.69496	14.436401	13.811082	-22.947155436986204
216680863861815680	56.0801833161	32.12628963176	16.382368	18.259493	15.080367	3.179126	13.138611	12.827286	12.530115	12.103763	-6.5860575457077815
216680928285636096	56.11121148625	32.13896385444	17.372114	19.257975	15.958456	3.299519	12.568316	12.254723	12.163148	11.600784	-48.550470569201025
216682444409767936	56.09302777632	32.20016776863	15.944566	17.684744	14.661537	3.023207	13.151579	12.71296	12.299219	11.673666	-88.58365027316755
216682513129243264	56.07743215813	32.21473054442	18.706783	19.828508	17.335423	2.493086	12.863291	12.25259	11.801672	11.322401	-64.27739377025031
216693954922130432	55.99546673051	32.19084664821	15.891031	17.4451	14.578859	2.866242	12.292854	11.838944	11.630945	11.054937	-2.210026739818777
216694603461518208	56.02500511018	32.25890608038	18.578136	20.69869	17.067696	3.630995	15.273631	14.842566	14.482931	13.8975	-26.54649908648751
216695256295900672	55.95341712662	32.26427711763	16.588135	18.59201	15.246967	3.345043	13.654764	13.182681	12.694295	11.991574	-12.59027312666037
216695634253464576	55.99400480739	32.29095550145	16.15183	17.522404	14.466255	3.056148	12.678374	12.310664	12.02391	11.308278	-145.51329778936125
216701033028221440	56.23393158311	32.15420230617	14.521962	16.100838	13.284246	2.816591	12.048044	11.719073	11.572461	11.174041	-6.214467483232864
216701926381421568	56.17735769182	32.16728452898	18.745459	19.72243	16.974285	2.748144	13.723769	13.280625	12.927392	12.416217	-10.895387666736257
216706290068182016	56.14221754121	32.27657011598	18.350334	20.255827	16.889174	3.366653	14.543779	14.171496	13.918973	13.382585	-92.85571652280771
216706942903208320	56.12970571724	32.31343207058	18.853565	20.793758	17.450533	3.343225	14.472417	13.999439	13.591156	12.973252	-7.809218711297454

However, there are some considerations that need to be taken into account when examing the LAMOST spectrum for each one of the candidates, obtained with our second code. There are 4 objects (highlighted in gray) that should not be taken into account as the LAMOST spectrum disclose some problems.

Figure 9 shows the emission spectrum for the aforementioned objects. The first one in the second row disclose a spectrum wih high noise, which do not allow a clear verification of the equivalent width. The other 3 spectrums can be attributed to more than one object close to each other, considering that the resolution of the telescope do not allow to discriminate from one another. This objects should not be taken into account until further investigation on them is made.

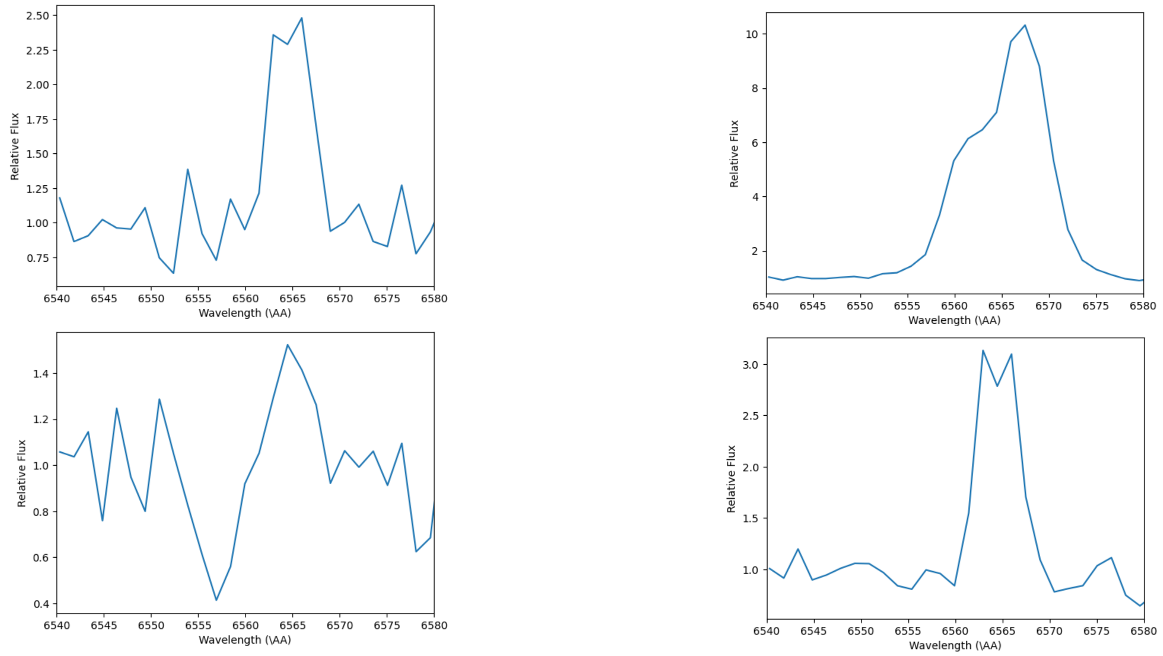

Figura 9: Emission spectrum obtained by spectroscopy for the highlighted regions.

5. Conclusions

It was possible to perform a study of IC348 N and S using Spitzer IRSA/IRAC and LAMOST survey data. It was found the presence of 18 T Tauri star candidates in IC348N region and a their respective infomation was retrieved, matching with GAIA EDR3 data release. There are 4 objects that need further study to make a valid classification. It was found that there are no candidates for T Tauri stars in IC348S region. Moreover, there are several objects that may possible be classified as T Tauri stars, due to their position in a color-color diagram, however, as there is no LAMOST information regarding those objects, we can not include them in this catalog. Further study with new data releases may disclose new T Tauri star candidates in this regions.

Referencias

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