Infrared and Radio Observations of Star-Forming Regions

What is the future fate of this region in space?

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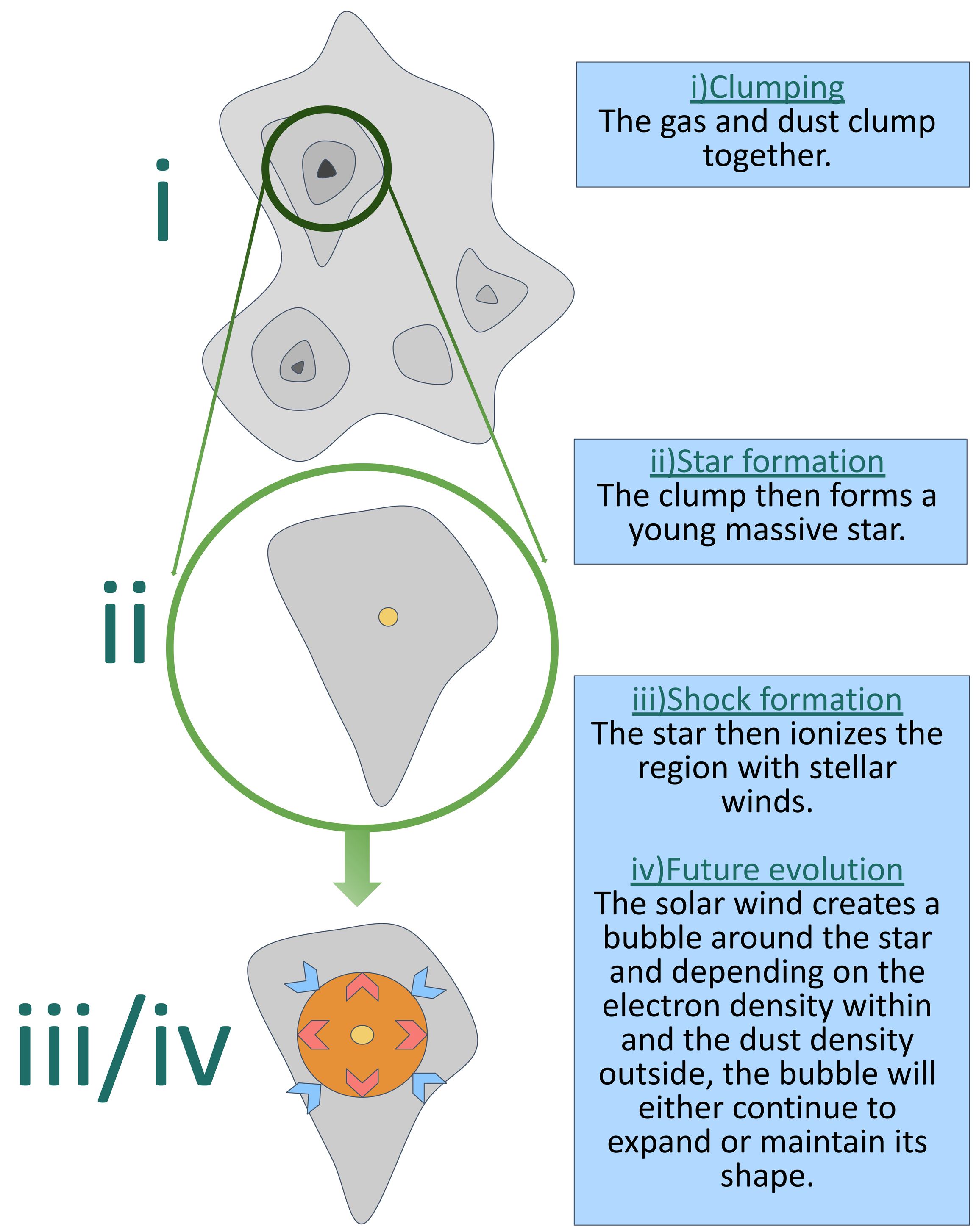
Abstract

During a related research project which is focusing on studying shock tracers inside massive star-forming regions with High-Mass protostars, our research group wanted to explore the attributes of these regions themselves. The purpose of this research is to perform an analysis and get a better understanding of the physics and effects taking place within and around these stellar formations. Utilizing an astronomy software called DS9[1] to compile the images and the NASA Spitzer Space Telescope data archive[2], I created the foundation for the analysis of our sources. Then, using another program called CASA[3], I performed this analysis of the 19012+0536 left lobe region source. In this poster, I present my results and how they will help our research group create a more continuous narrative of the processes occurring in these regions. This work is relevant because of its importance to our larger research project and because this is the first analysis of its kind on this source, allowing for anyone to use it as a basis for further research.

Background

Our team is analyzing mass outflows from massive young stars and to help create a more comprehensive evolutionary story behind them I set out on understanding the structures that help form them. These structures are called ionized atomic hydrogen (HII) regions, which are massive clumps of gas and dust in space, sometimes called star-forming nurseries.

Evolution



Goal

We want to study each of these processes; however, my main goal is to determine if this ionized bubble will continue to expand or maintain its structure in the future. Answering this question will help our team better understand the astrophysical processes that lead to mass outflows of these young stars.

Figure 1. Evolution of HII region for High-Mass protostars diagram.

Infrared Observations

DS9 Analysis:

- Purpose: A software that was made to study optical and infrared astronomy sources used to create color images for visual and CASA[3] analysis.
  - These images allows for the study of the structure, wavelengths, and possible effects taking place in the region of study.

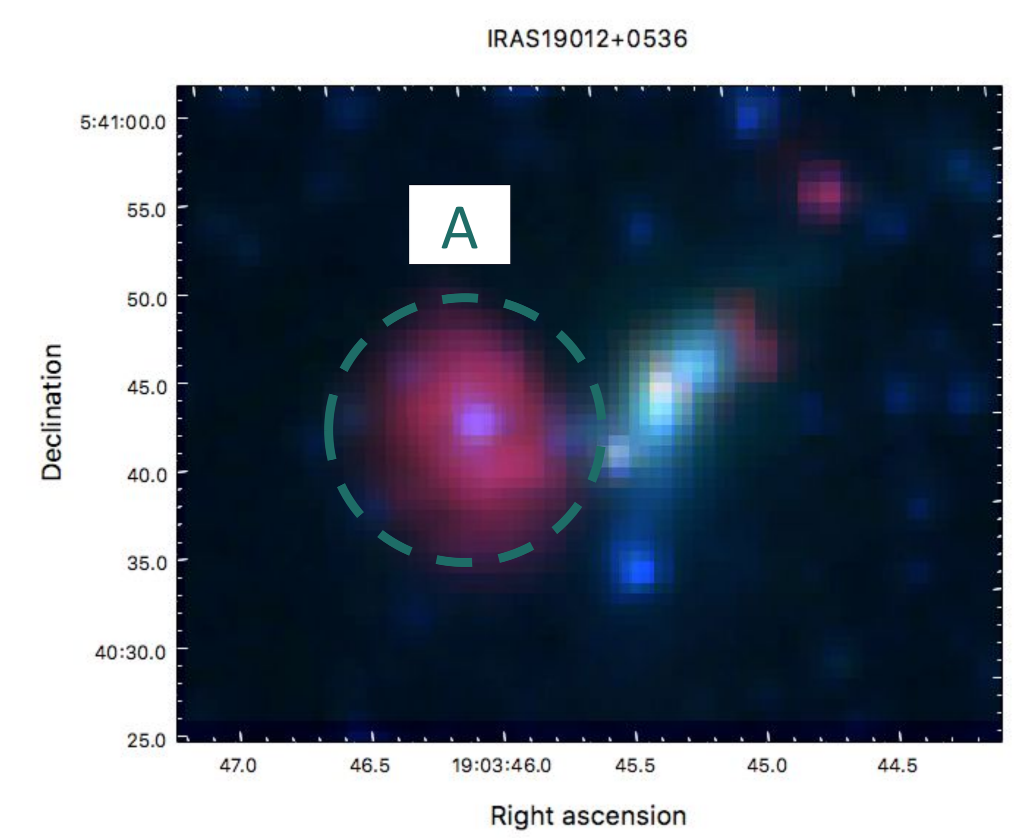


Figure 3. DS9[1] image of 19012 region using 3.6µm (blue), 4.5µm (green), and 8.0µm (red) Spitzer Space Telescope[6] data. Region (A) is 19012 source under study.

Figure 3. Spitzer Space Telescope render from NASA[6,7].

Radio Observations

CASA Analysis:

- Purpose: A software developed for radio interferometry analysis which was used to gather data on the flux density, frequency, and size of the source.
  - This data is the basis for numerical and computational analysis.

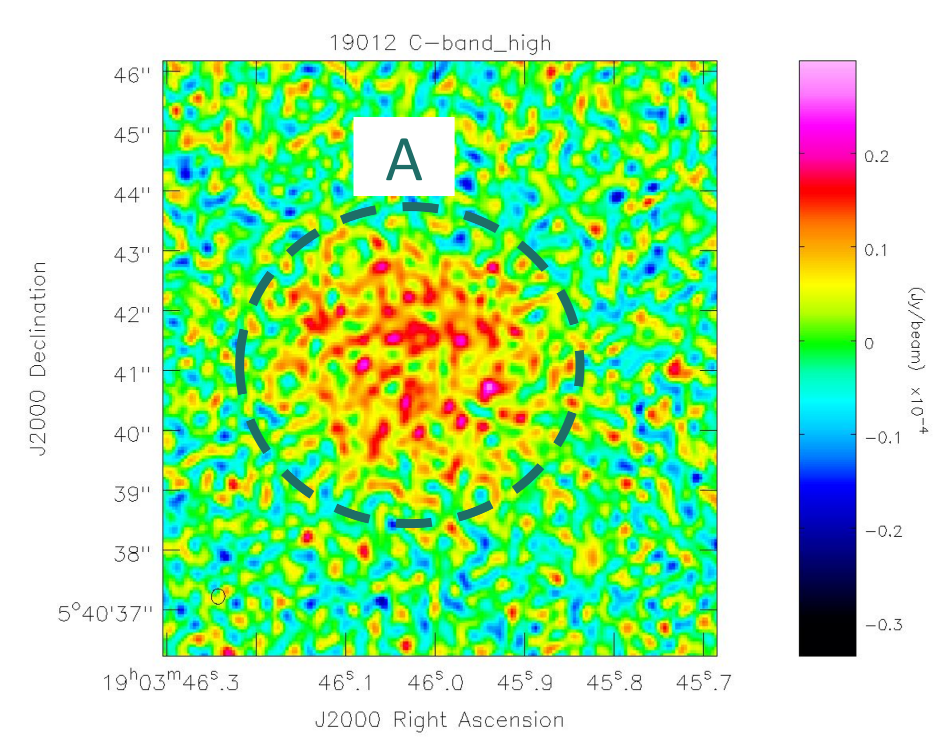


Figure 2. *Left image*: CASA[3] image of 19012 region in the radio regime at 7.4GHz. Region (A) is 19012 source under study. *Right image*: VLA[8] radio telescope used to get radio observations.

Analysis

Numerical Analysis:

- Finding electron density within bubble[4]:

$$(eq.3) U = r n_e^{2/3} = 4.553\left[\frac{1}{a(v,T_e)}\left(\frac{v}{GHz}\right)^{0.1}\left(\frac{T_e}{K}\right)^{0.35}\left(\frac{S_v}{Jy}\right)\left(\frac{D}{kpc}\right)^2\right]^{1/3}$$

  - U(excitation parameter), r(radius of source), n_e(electron density), v (frequency), T_e (Temperature), S_v (flux density), D (Distance to source)

- Finding number density of dust outside of bubble[5]:

$$(eq.1) M_d = \frac{d^2 S_v R_g}{B_v(T_d) k_v}$$

  - M_d(mass), d(distance to source), S_v(flux density), R_g(gas-to-dust ratio), $B_v(T_d)$ (Planck function for dust temperature using frequency and approximate temperature of dust), k_v(dust opacity)

- Pressure equilibrium:

$$P = nkT$$

$$n_e kT = n_d kT$$

$$(1109.1 cm^{-3})(10^4 K) = (638665 cm^{-3})(50K)$$

  - P(pressure), n,n_d(number density), n_e(electron density), k(boltzmann constant), T(temperature)

Results

The region is not in a pressure equilibrium and an expansion should take place. Considering the error within the values referenced, the region may be in pressure equilibrium, hence refinement and additional measurements is necessary to close in on a more accurate pressure equilibrium value and conclude without a doubt the regions true future.

Conclusion

The findings suggest that the bubble will expand; however, more precise data is needed to say for sure. This work aligns with current theory giving credence to the methods used and provides a basis for future research since these sources mechanics have never been analyzed before.

Future Directions

Our research group wants to apply this analysis to all the sources currently under our study and refine the calculations to a higher precision. This source has gone without evolutionary analysis until this project; however, to understand how these structures evolve in space, provides great insight into the future formation of the universe around us and allows us to test fundamental theories to their extremes. This project is a small step into the insight of the physical properties occurring within these regions and provides a story into the study of cosmological evolution.

Contact Information and References

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References