Analysis of SN-1604 & G11.2-0.3 using X-Ray Astronomy

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Abstract

By combining X-ray and infrared imagery, it is possible to identify the composition and therefore type of a supernova. The classification of SN-1604 could not be identified, but several important characteristics could be.

Background Information

In 1604, Johannes Kepler observed a new star and documented its position and brightness over almost a year (Kepler, 1606). Based on Kepler’s observations, we would now classify his new star as a Type 1a supernova, and it now goes by multiple names including Kepler and SN-1604. The corresponding object, called a supernova remnant, was observed by the Chandra X-ray Observatory between 2000 and 2014. My goal was to learn how to do x-ray astronomy, and to analyze these Chandra data of SN-1604.

A supernova remnant is an explosion that occurs at the end of the star's life. There are 2 different types of supernovas. There are type 1 supernovas, which are broken down into type 1a, type 1b, and type1c. There are also type two supernovas. Type 1a supernovas are unique because they are caused by an exploding white dwarf. An exploding white dwarf is when a white dwarf star is orbiting a companion star and begins to pull mass off the companion star and then the white dwarf explodes, usually throwing the companion star out of the system. This type of supernova occurs to stars that are closer to the mass of our Sun so the white dwarf that is formed is closer to the Chandrasekhar limit.

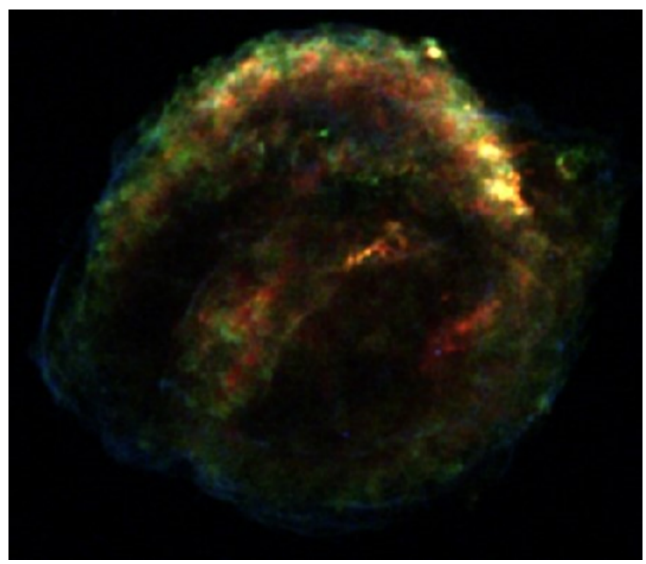
Type 1b, type 1c, and type 2 supernovas are core collapses. These types of supernovas can only happen if a star has at least 8 times the mass of our sun. The iron core collapses, and the shockwave bounces in the center and the shock goes back out creating the supernova. The two supernova remnants I worked with were SN-1604, more commonly known as Kepler’s Supernova and G11.2-0.3. I did most of my work on SN-1604 which is a type 1a supernova.

Materials and Methods

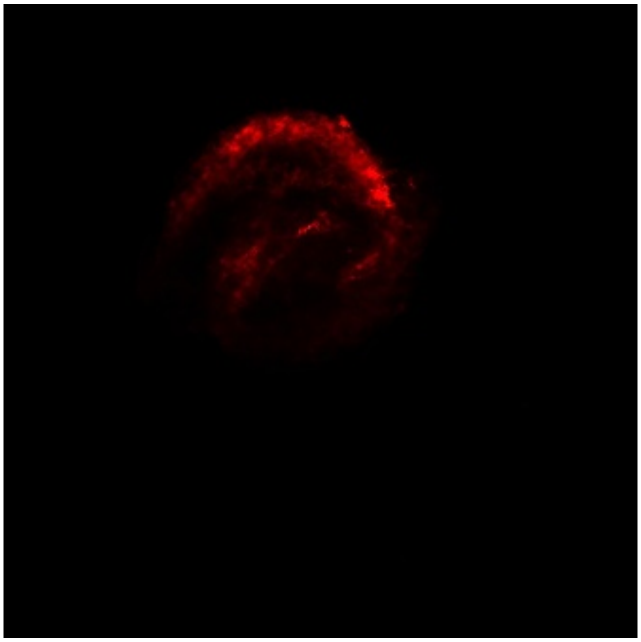
The summer research goal was to ultimately learn how to do x-ray astronomy and SN-1604 is one of the most recent supernovae in the Milky Way so there is a lot of data on it. All the x-ray data used was from the Chandra x-ray telescope. All the coding on the files was done in a Unix-like operating system and the coding to make the graphs and spectrum was done in a version of Python called Sherpa.

Discussion

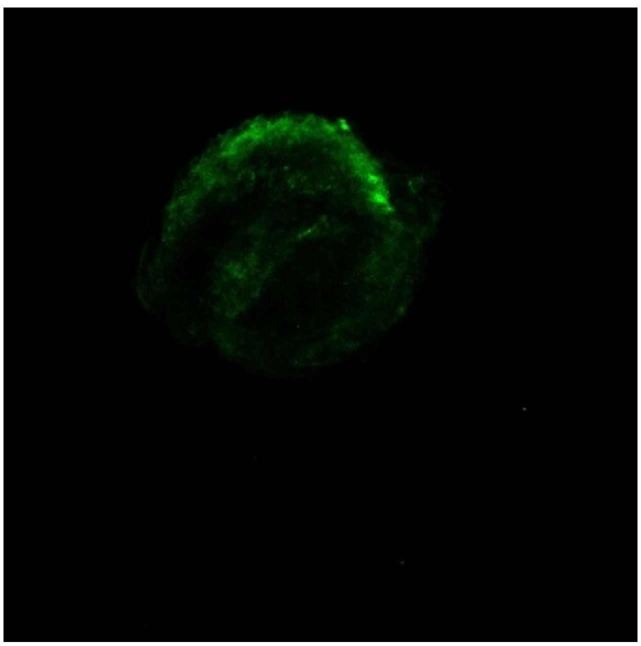
When the SN-1604 data was first downloaded, I thought the point source in the center looked like a neutron star, but it turned out not to be and is likely tenuous hot gas from a reverse shock. The images show the energy ranges. The lower energy ranges are much more visible, and, on the verge of the spectrum, it also has more counts showing more energy at the lower energy levels. If you look at the orange picture at the bottom that is G11.2-0.3 with a filter so it is easier to see. The point source in the center is a neutron star unlike in SN-1604. At the bottom left of the picture you can see the shocks. If you look at the blue picture on the bottom you can see green and red. This picture is a mix of x-ray pictures and infrared pictures (Keohane, et al.). The blue in the picture is the x-ray and the green part is the iron line of the supernova, and the red part is the H2 region of the supernova.



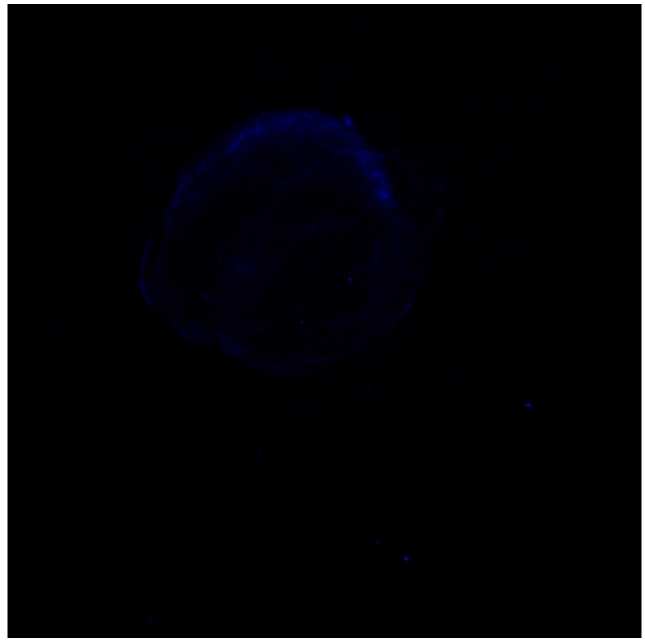
Full Range Image of SN-1604



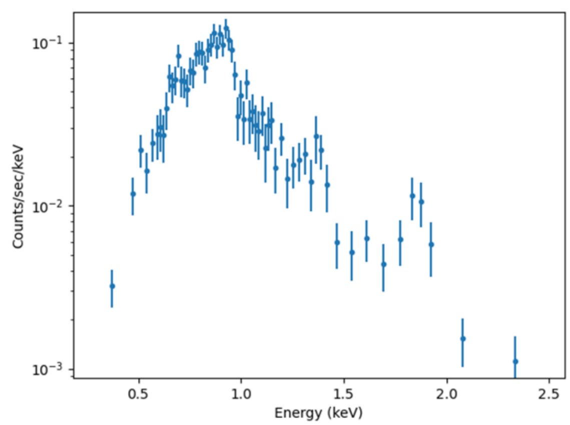
Cut of the image showing energy levels of 0.2-1.5 keV



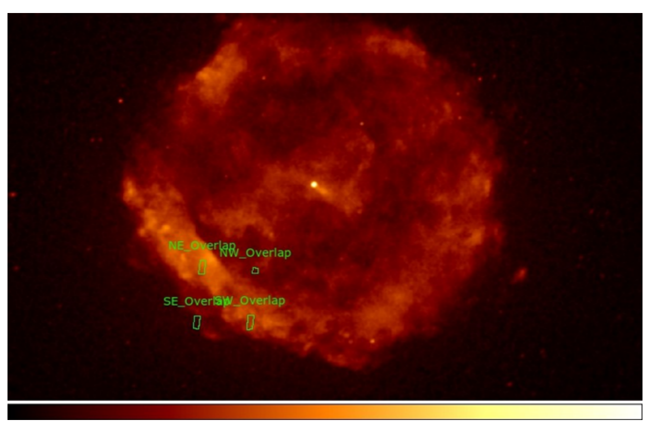
Cut of the image showing energy levels of 1.5- 2.5 keV



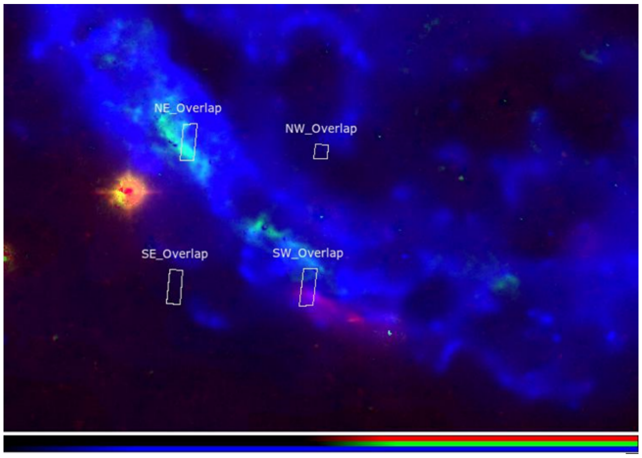
Cut of the image showing energy levels of 2.5-8.0 keV



A spectrum of the full-range image



X-ray image of G11.2-0.3



X-ray image (Blue) combined with infrared data of the FE line (Green) and the H2 line (Red)

Conclusion

The purpose of the summer research was to learn how to do the basics of x-ray astronomy and I think I have done that. I learned how to code in a Unix-like operating system which was where most of the coding was done. I learned how to download and analyze x-ray data. I built models and full color images of these supernova remnants. Most of my research was done using the Chandra website. The website which was called CIAO had tutorials that showed you how to download and process the data. CIAO was vital in showing us how to learn how I was supped to make all the data used in this project.

My results ended up mostly being images of the supernovas and the cuts of them. If I had more time, I would have liked to make more models. The part that took the largest amount of time was the fact that instead of doing the work on one set of data I was doing the reprocessing on 8 different data sets. I used 8 data sets because with more data my images and my results would be much clearer. I think this was very productive and if I had more time I would have liked to see more of the statistical results. I will continue to do x-ray astronomy in my free time on different supernova remnants using the skills I learned.

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