Forensic Astronomy: Collecting Chemical Footprints from Ancient Supernova Explosions

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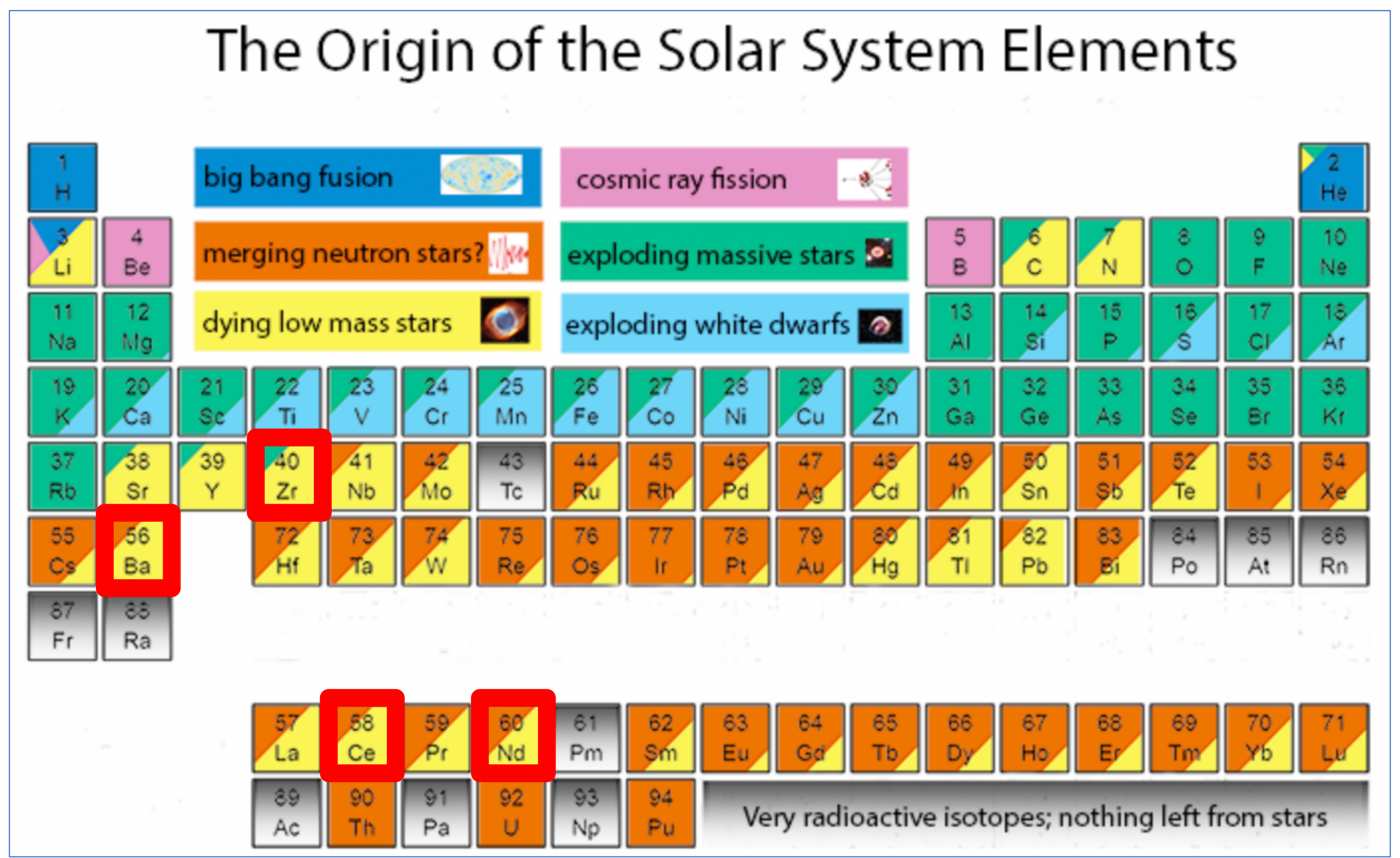
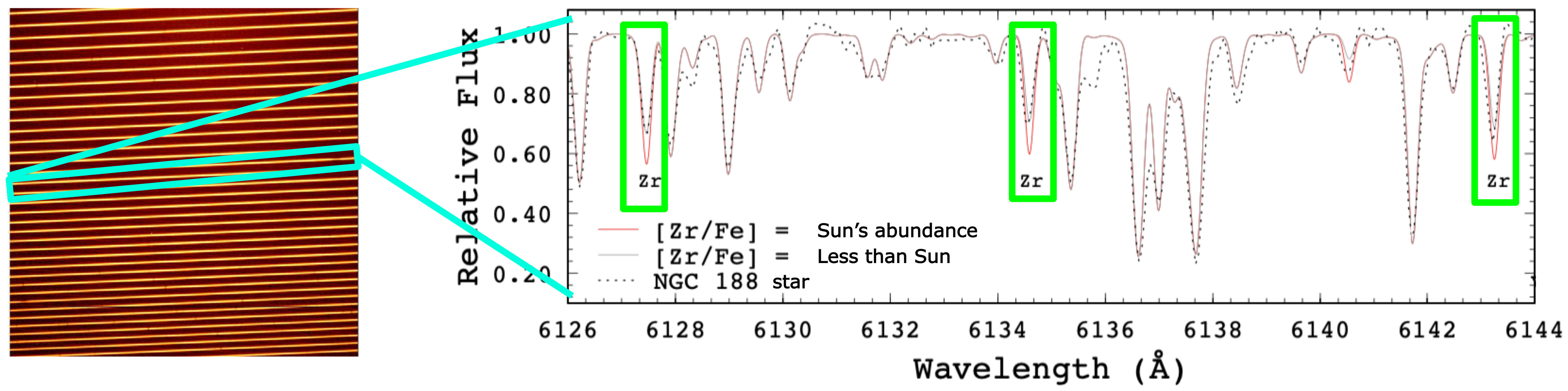
Abstract: The creation and evolution of elements throughout time across the Milky Way disk provides a key constraint for galaxy evolution models. To provide these constraints, we are conducting an investigation of the zirconium, neodymium, cerium, and barium abundances created in supernovae explosions, for a large sample of open clusters. The stars in our study were identified as cluster members by the Open Cluster Chemical Abundance & Mapping (OCCAM) survey that culls member candidates by Doppler velocity, metallicity, and proper motion. We have obtained new data for the elemental abundances in these clusters using the Subaru Observatory 8-m telescope in Hawai'i with the High Dispersion Spectrograph (HDS). Analyzing these neutron-capture abundances in star clusters will lead us to new insight on star formation processes and the chemical evolution of the Milky Way galaxy.

Data Collection: The data was collected from the Subaru Telescope atop Mauna Kea in Hawai'i using the High Dispersion Spectrograph, an instrument that provides extremely high-resolution spectra in the visible light region.

Chemical Enrichment: After the Big Bang, the universe was comprised solely of hydrogen and helium. Stars were formed from these clouds of hydrogen and helium, but as they age, they form heavier and more complex elements through nuclear fusion. When stars die, they explode and expel the elements they created back into the galaxy, causing the next generation of stars to start with heavier elements.



Spectroscopy Methodology: The spectrum of a star measures and graphs the amount of light it gives off at different wavelengths. The spectra display absorption lines, which show us the specific wavelengths at which light is being absorbed by the elements of the star's atmosphere. Each element shows a specific and unique absorption line, meaning the absorption lines on spectra are like a fingerprint left behind by the element present. In this project, we use the raw spectra of stars which undergo a series of data reductions and normalizations to give us the resultant spectra we can analyze. The figure below displays an example of a single line of raw spectra after reduction and normalization. This allows us to analyze the absorption lines of elements present and evaluate an abundance of the particular elements in the star. We will be looking specifically at elements heavier than iron, namely zirconium, neodymium, cerium, and barium.



Galactic Chemical Evolution: Stars in a cluster are born from the same gas clouds, meaning they are the same age and fairly homogeneous in chemical composition. We know from chemical enrichment that the elements they are composed of are built up over multiple generations, so by analyzing star clusters of different ages, we can build a timeline for the formation of elements through the history of the galaxy.

Moving Forward:

1. Using the data collected from the Subaru Telescope, we will reduce and normalize the spectra in order to analyze absorption lines.

Where We Are Now

2. Once we have reduced the spectra, we will be able to measure the stars' stellar parameters, such as their temperature and overall abundances.

3. We can then measure the individual element abundances of zirconium, neodymium, cerium, and barium.

4. The final piece will be to analyze galactic trends and see how our population of stars fits into the bigger picture of the chemical evolution of the galaxy.

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After the Big Bang, the Universe was comprised solely of hydrogen and helium. During a star's lifetime, it creates heavier and heavier elements. When a star dies, it can create even heavier elements, such as zirconium and neodymium, and disperses them into the Galaxy, which is called Chemical Enrichment. This cycle repeats itself, until we are left with a new generation of heavy elements, or metal-rich, stars. Using observations from the Subaru Telescope in Hawai'i, we measure the elements in star clusters, that have known ages, to determine how and when heavy elements were built up in the Milky Way.

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