

The Galactic Chemical Evolution



Credit: NASA, JPL-Caltech, Susan Stolovy (SSC/Caltech) et al.

13.7 billion years ago, the simplest elements were formed; hydrogen and helium. Stars are formed of these elements, fueled by hydrogen. The temperature inside stars allows for a process called nucleosynthesis, where hydrogen is burned into helium, releasing energy as heat. This process occurs during the lifetime of a star, until the star burns all the hydrogen inside.

The strongest tool of an astronomer is light. Light can be split into its constituents, known as spectroscopy. In the 1850s, Gustav Kirchhoff explained that the dark lines in our Sun's spectrum, also known as the Fraunhofer lines, are related to the material present in the atmosphere. Elements on the surface of a star absorb specific colors, creating darker lines in the spectrum of light.

Elements are formed in different environments. The elements in the periodic table are arranged according to the number of protons in the nucleus of an atom. In the core of stars, elements can be formed up until iron, the 26th element in the periodic table. With similar formation processes in stars, the periodic table can be split in four groups. The elements lighter than iron are divided into the odd-elements, which are odd-numbered, and alpha-elements, which are even-numbered. In the periodic table, the elements around iron are referred to as iron-peak elements, named due to their abundance in our Solar System. Elements heavier than iron are formed through a process called neutron-capture, where the nucleus of an atom grows by capturing the free neutrons, which is also a building block in a nucleus. Which elements are formed inside stars are also dependent on the mass of the star, because the mass determines the temperature inside stars.

The mass of a star determines the fate of a star. More massive stars have shorter lives, as they burn their hydrogen faster. The short-lived, massive stars form heavier elements, enriching our Galaxy through a spectacular explosion, known as a supernova. The material ejected by stars are building materials for the next generation of stars. Yet, the more abundant type of stars - much like our Sun - can live as long as the age of our Universe today. These long-lived, lower-mass stars enrich our Galaxy later, allowing us to analyze how the dust, that forms stars, has changed since the beginning of the Milky Way.

The cycle of stars forming from dust created by stars means that younger stars contain more heavier elements. As a star contains the information of their birth environment, observing several stars of different ages can tell us how their birthplace - the dust in our home Galaxy - has formed and evolved.

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