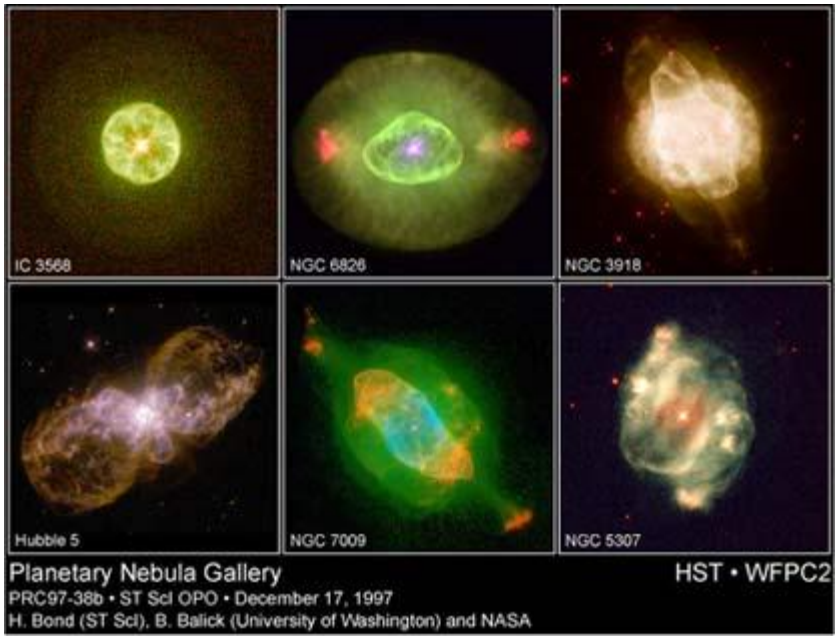
Planetary Nebulae Used to Determine Chemical Composition of the Early Milky Way Galaxy

Posted by Guy Pirro on 7/12/2008 11:58 AM



A planetary nebula forms when a star can no longer support itself by fusion reactions in its center. The gravity from the material in the outer part of the star takes its inevitable toll on the structure of the star, and forces the inner parts to condense and heat up. The high temperature central regions drive the outer half of the star away in a brisk stellar wind, lasting a few thousand years. When the process is complete, the remaining core remnant is uncovered and heats the now distant gases and causes them to glow. (Image Credit: H. Bond - St Sci, B. Balick - University of Washington, and NASA)

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A planetary nebula is a beautiful object created during the final stages of the life of a star. The wispy, colorful halo of gas making up the nebula and surrounding the dying star is actually material that was originally part of the star itself but has been cast off and is expanding outward into interstellar space. It glows as the result of being heated by the ultraviolet radiation produced by the dying star. The word planetary is really misleading, as these objects have nothing to do with the planets in our solar system. Rather, they acquired the name because when they were first observed in the 19th century their extended appearance (versus the point-like image of a normal star) reminded astronomers of the way planets like Uranus and Neptune appear in a telescope. In a galaxy such as our own Milky Way there are estimated to be several thousand planetary nebulae at any one time. Most of them are concentrated toward the plane of the Milky Way's disk, but a few are also know to exist in the halo and a number have been identified in the bulge of the galaxy as well.

What's so interesting about planetary nebulae? Astronomers are drawn to study these objects because they provide opportunities to analyze material that was once a part of a shining star. For example, by studying the chemical composition of the nebula we can gain an understanding about the material out of which the star originally formed. In addition, the abundances of certain elements such as carbon and nitrogen in the nebula reveal details about the physical processes that occurred within the star during its nuclear fusion lifetime. Studying planetary nebulae helps us to understand how a star changes, or evolves, during its lifetime.

But why and how does a planetary nebula form in the first place? Interestingly enough, it's related to the star's lifelong battle against the relentless force of gravity. In order to keep from collapsing on itself, a star maintains high internal gas pressure by creating its own energy through nuclear fusion. During most of the star's life the principal fuel for fusion is hydrogen, but as the star exhausts it supply of this element, it will rely increasingly on heavier, more complex elements. Ultimately, however, available fuels run out, the star becomes unstable, and it ejects its outer gaseous layers which expand outward and form the nebula. The lines in each spectrum can be analyzed to determine nebular properties such as chemical composition, temperature, and density.

The National Science Foundation (NSF) has awarded a three-year grant to Karen Kwitter of Williams College, Bruce Balick of the University of Washington and Richard Henry of the University of Oklahoma.

Their project, titled, "Planetary Nebulae as Probes of the Early Chemical History of the Galaxy and M31," is a collaborative effort, involving a team of astronomers from the US, Great Britain, and Italy, and includes undergraduate and graduate students as important participants.

By studying the distribution of the chemical elements in planetary nebulae, which are shells of gas cast off by sun-like stars as they die, the astronomers can uncover patterns of chemical enrichment that yield clues to how spiral galaxies were formed and how they have developed. A planetary nebula is a kind of "time machine": its chemical abundances reveal the composition of the Galaxy at the time and place where its ancestral star was formed billions of years in the past.

Carrying out this ambitious project will require, among other efforts, a search for previously undetected planetary nebulae in the outlying regions of the Milky Way Galaxy and M31 (the Andromeda Galaxy), followed by observations of their spectra to determine their chemical compositions.

A pilot project to derive chemical abundances in known planetary nebulae in the outer reaches of the Milky Way has already been completed.

For more information:

http://www.williams.edu/admin/news/releases/1655/

http://www.williams.edu/Astronomy/research/PN/nebulae/nebulaegallery.php

http://www.noao.edu/jacoby/

http://www.williams.edu/Astronomy/research/PN/nebulae/