EDITORIAL

Stellar Birth and Death

Stars are the most fundamental components of the visible universe. They provide reference points in the sky, distance markers for cosmologists and tracers of dark matter; serve as the basis for understanding the composition and origin of our solar system; and are companions used to find planets, brown dwarfs, and black holes. Our ability to understand and to use stars effectively for these and other applications depends on knowledge of stellar life cycles. Our view of stellar evolution has changed and progressed rapidly in the past 5 to 10 years, due in part to technological advances, including bigger and better charge-coupled devices, improved ground-based telescopes such as Keck I and II, and continued spectacular results from orbiting satellites such as the Hubble Space Telescope, the Röntgen X-ray Satellite, and the Solar Heliospheric Observatory. Given this progress, the recent discoveries of extrasolar planets (see News story on p. 1336) and brown dwarfs, and the possibility that we may soon identify a black hole and a source for gamma ray bursts using the characteristics of star-like objects near these phenomena, it seems fitting to highlight some advances in stellar research in the nine Articles in this special issue.

A star is born by the gravitational collapse of a cloud of dust and gas. If the condensing spherical mass cannot grow large enough, then it slowly gets colder and fades, becoming a brown dwarf. If it grows enough to sustain hydrogen fusion, a main sequence star, like our sun, is formed. Eventually hydrogen is exhausted, the star expands to a red giant as it feeds off other nuclear reactions, and finally the red giant collapses into a small, dense white dwarf, when these reactions cease. In some cases, the collapsing star throws off excess mass as a gaseous envelope, called a planetary nebula. More massive stars tend to die in rapid energetic outbursts called supernovae explosions that produce white dwarfs; or if the remnant core is too massive, collapse continues until most energetic particles are converted to neutrons that stabilize the core into a neutron star. The most massive stars, with the shortest lifetimes and the most energetic supernovae explosions, cannot collapse into white dwarfs or neutron stars; instead, they collapse into an even smaller, denser core from which not even light can escape: a black hole.

The first five Articles discuss the early part of the stellar cycle. Kulkarni (p. 1350) focuses on the direct detection of a brown dwarf and discusses how brown dwarfs may be a link between planets and stars. O'Dell and Beckwith (p. 1355) describe the dynamics of stellar birth, focusing on star-forming regions in the Orion Nebula, which show that young stars do not just collapse into spheres of gas but produce jets, winds, and possible planet-forming disks of dust. Arnett and Bazan (p. 1359) discuss the latest progress in understanding nucleosynthetic processes, including the identification of presolar grains in meteorites and the use of high-energy density laser experiments to simulate thermonuclear reactions. Neuhäuser (p. 1363) focuses on the x-ray emissions from protostars, which can be seen through molecular clouds that surround protostars. Many protostars are binaries and interact with the circumstellar disk, possibly allowing planet formation within the disks. Burgarella (p. 1370) reviews globular clusters, which are regions of colliding galaxies that produce bursts of star-forming regions encased in dense envelopes of gas. Globular clusters help us understand galaxy formation and the evolution and age of the universe.

The death of stars is perhaps most obvious in supernovae explosions. Supernova 1987A, because it was discovered early in its explosive history and was relatively close to Earth, has provided a wealth of information about the chemical and physical evolution of supernovae. Chevalier (p. 1374) reviews the progress made in understanding Type II supernovae, particularly 1987A and 1993J. Nomoto, Iwamoto, and Kishimoto (p. 1378) discuss Type Ia supernovae, which are believed to represent the thermonuclear explosions of accreting white dwarfs and are used to estimate the age of the universe and distance to its edge. On the quieter side of stellar death, Weinberger and Kerber (p. 1382) describe the diverse morphologies of and applications for planetary nebulae. Spectroscopic observations of planetary nebulae in the halos of galaxies confirm that we cannot account for most of the dark matter in the universe. Finally, Kaaret and Ford (p. 1386) review x-ray binaries, which consist of a neutron star or black hole and a compact star. Understanding how material flows from the star to the black hole will help to identify the event horizon of a black hole.

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