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Distances to Planetary Nebulae

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When astronomers want to determine the properties of an object in the universe, they need a reliable distance to that object. Consequently there always has been much effort to find methods for distance determination. In the case of planetary nebulae, distances are very difficult to determine. Several methods have been tried but individual distances in general are still uncertain by a factor of two to three, sometimes even more. We have used an in principle powerful method, the "extinction method" to derive accurate distances for about 10 planetary nebulae.

The Importance of Accurate Distances

Planetary nebulae are believed to represent a late stage in the evolution of the many stars in the Galaxy with intermediate masses. During the planetary nebula phase, the star loses mass that becomes visible as a gaseous nebula which surrounds the central star.

Without an accurate distance to a planetary nebula important parameters such as nebular radius, nebular mass, luminosity and radius of the central star remain unknown. It is important to know the nebular mass, for example, because it determines the amount of gas that is returned to the interstellar medium by the planetary nebula phenomenon. This mass return has a large influence on the evolution of the entire Galaxy.

We also need accurate distances to many planetaries in order to determine their distribution in the Galaxy. This distribution can then be compared with distributions of other kinds of stars in order to try to determine which stars pass through the planetary nebula phase and which do not. Especially a comparison with the galactic distribution of white dwarfs and red giants is very interesting since it is believed that the planetary nebula phase lies between the red giant phase and the white dwarfs. Once the distance to a planetary nebula is known, the luminosity of the central star can be determined. The effective temperature of the central star can usually be derived so that the star can then be placed in a luminosity–temperature diagram. Many positions of central stars in such a diagram define in fact how temperature and luminosity evolve with time. This enables astronomers to check theoretical calculations of the evolution of stars with different masses.

Reasons Why Standard Methods Cannot be Applied

The reason that most planetary nebulae have unknown distances is that standard methods for distance determination are usually not applicable. All nebulae are much too far for distance measurements by means of trigonometric methods. With our knowledge about normal stars it is usually possible to determine their intrinsic luminosities by means of spectroscopy