Galaxy structure

Two kinds of halo gas identified

from Joel Bregman

ALTHOUGH most of the cool gas in our galaxy lies in the galactic disk, it is not entirely confined there and the study of gas above and below the disk (halo gas) has been an especially vigorous area of research during the past few years. Unfortunately, it has frequently been difficult to discriminate between disk and halo gas, for it is not possible to determine distances to gas clouds and we can only look at the halo gas through the disk. In a recent paper C. E. Albert has used a new approach[1], a study of low ionization gas within 8,000 light years of the disk (the lower galactic halo). She has conclusively shown that a considerable amount of neutral (cool) gas exists in the lower galactic halo and that there are two kinematically distinct types of halo gas.

Gas is believed to exist in the halo in several different forms[2]. Weak radio continuum emission has been attributed to synchrotron emission from cosmic ray electrons that may extend up to 30,000 light years from the disk[3,4]. Plasma at temperatures of millions of degrees may also permeate the halo and be responsible for part of the diffuse X-ray background (0.1–2 keV)[5]. Virtually nothing is known about the vertical distribution of this gas except that it is unlikely to extend beyond 30,000 light years from the disk. Radio telescope surveys have revealed the presence of neutral hydrogen gas at a few hundred degrees kelvin but with unusual velocities[6,7]; this gas is presumed to lie in the halo as well. Finally, absorption line spectroscopy in the optical and ultraviolet bands has been used to demonstrate the presence of halo gas with a temperature in the range 10^3–10^5 K[8–10].

Optical and ultraviolet spectroscopy have been powerful tools for analysing the properties of halo gas. By detecting absorption lines caused by gas intervening between the Sun and a background source (a star or quasar), one is able to estimate the column density, vertical distribution, chemical abundance and temperature of the gas. Strong absorption is commonly detected for the ultraviolet resonance lines of C IV and Si IV, which is interpreted as evidence for warm gas (10^4–10^5 K) lying between 1,500 and 10,000 light years above the disk[9–11]. For neutral gas ($< 10^3$ K), a more precise study of the vertical distribution has been made by comparing the total column density (from the 21 cm HI emission line) with the column density between the Sun and a halo star (using the Ly α line of neutral hydrogen)[12].

There is a vast amount of gas above the thin disk of the galaxy (half-thickness about 300 light-years) and about one-third of the total column density of neutral gas is beyond a height of 3,000 light years. However, little neutral gas exists further than 6,000 light years from the disk. Albert has added to our understanding by comparing the difference in absorption for pairs of stars, one of which is just above the galactic disk and the other in the halo. She shows that the halo is rich in gas and distinguishes between two types of neutral halo gas: a layer of gas similar to disk gas that has a scale height of about 3,000 light years, and higher velocity gas richer in certain heavy elements (Ti, Ca, and Na) that is found only above the disk. Whether or not there is a true difference between the distribution of warm and neutral gas and how these components are related to the million degree gas and the cosmic rays remains to be seen.

The absorption-line gas is rotating, but not precisely with the galactic disk. This has been clearly shown by Albert and others[13] who demonstrated that the velocities at which absorption against halo stars is observed are considerably different from these expected for corotating gas. Evidently, these gas clouds have large peculiar velocities with respect to a corotating halo. The data are qualitatively consistent with features of a corona that rotates more slowly than the disk and of galactic fountain models. More data are needed before the various models can be tested critically and more studies along the lines of Albert's would be valuable. □

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Palaeontology

Small companions for early dinosaurs

from Michael Benton

FOSSILIZED cave systems around Bristol, England, have yielded an important fauna of small reptiles dating from the times of the early dinosaurs, about 200 million years ago. Until recently, these were thought to be specialized upland faunas because the animals were rather different from those of the typical lowland dinosaur beds. Strong evidence has now, however, been presented against this view, and new information on the dating and palaeoecology of these remarkable faunas has also been given[1–6].

Fossil mammal teeth were first found in the Bristol fissures by Charles Moore over 100 years ago[7], and the first reptile remains were described[8] in 1939. These consist of the bones of a small lizard-like animal (*Clevosaurus*), very like the unique living tuatara, *Sphenodon*, from New Zealand. Many more important mammal and reptile fossils have been collected since then from dozens of fossil caves in South Wales and around Bristol. The reptiles include a remarkable small gliding animal called *Kuehneosaurus*, isolated bones of the carnivorous crocodile-shaped *Rileya* and the dinosaur *Thecodontosaurus*, a crocodile, and various as yet undescribed sphenodontids and small archosaurs (crocodiles/dinosaurs/thecodontians). The latest new forms to be described have been *Gephyrosaurus*[5,6], a 40-cm long lizard-like animal, and *Planocephalosaurus*, a small sphenodontid[3].

The dating of the fissures has always been a problem. Some may be late Triassic (Norian) in age, others Rhaetic, and others early Jurassic (between about 190 and 225 million years ago). Some of the South Wales fissures have been dated as Rhaetic or early Jurassic on the basis of plants, spores and gastropods[9]. One of the fissures near Bristol has yielded more abundant spores which suggest a Rhaetic age[1]. The main fissure sites, and the reptiles that they have produced are described in references 1, 4, 9–11.

At the end of the Triassic period, the scenery around Bristol consisted of limestone hills in which deep fissures and caves formed. The climate was subtropical with wet and dry seasons, and the vertebrate fauna consisted of dinosaurs, small lizard-shaped reptiles and early mammals. Occasionally, these animals fell into the fissures, or were washed in by flash floods with mud and sand. The habitat was assumed to have been a rocky 'upland',

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