tion of impact craters on the Canadian Shield and the effect on these craters of glacial exhumation. Two possible theories have been put forward to explain the observations. The classical one is due to Baldwin (*Icarus*, **14**, 36 ; 1971) and considers the Canadian Shield as a stable platform on which craters have steadily accumulated throughout Phanerozoic time. All craters of diameters greater than 10 km still remain, only smaller ones being lost by erosion. On the other hand, White (*Bull. Geol. Soc. Am.*, **83**, 1037 ; 1972) suggests that Pleistocene glaciation has eroded a significant depth of rock ; before this the Shield was an area which accumulated flat-lying sediments much as the central part of the United States. White's theory explains why Palaeozoic and Mesozoic craters are found on a Precambrian surface and why Phanerozoic marine sedimentations are present in almost all the Canadian craters. The two theories also predict different influx rates. The distribution by age of Phanerozoic craters shows a peak 350 m.y. ago.

Now lunar investigations show that lunar cratering has been declining steadily for the past 4,000 m.y. with a half life of 250 m.y. If the cratering rate on the Canadian Shield was similar, early Phanerozoic craters would be four times more common than those formed in the past 100 m.y. Continuous erosion obviously has the opposite effect, making older craters harder to find. With erosion one would expect the crater age distribution to peak in recent times. In fact the opposite is true and there are considerably more old craters (ages between 250 m.y. and 500 m.y.) than new ones (ages less than 250 m.y.). Thus Baldwin's theory, which postulated a variable influx rate peaking some 350 m.y. ago, needs modification and Dent concludes that the age distribution of Canadian craters can be explained with a geological history of Canada based on White's glaciation theory and that no variation in the influx rate need be evoked. So the influx rate to the Earth is slightly dissimilar to that to the Moon. Tentatively the Earth influx rate can be put at such a value that one crater of diameter greater than 1 km forms every 50,000 yr. D. W. H.

Blowing Bubbles

THE recent discovery that clusters of galaxies also contain a detectable amount of hot gas in which the individual galaxies are immersed calls for a re-examination of radio galaxy models. Such a re-examination has now been carried out by Gull and Northover of the Mullard Radio Astronomy Observatory at Cambridge and their analysis is reported on page 80 of this issue of *Nature*.

Until recently, little thought was given to the existence of material in the space between galaxies—the intergalactic medium as it is called. It has been generally accepted that intergalactic space is the closest thing to a vacuum that one is likely to come across in nature. The fact that galaxies occur in clusters has modified that view only slightly—the space between galaxies in a cluster has generally been assumed to be a little less like a vacuum than the space between clusters, but in both cases only an upper limit can be given to the amount of material present.

Like much else in astronomy that concept was changed with the launch of the first X-ray satellite in 1970. The Uhuru satellite detected enough X-ray emission from clusters of galaxies to indicate the existence in these clusters of clouds of hot gas. Where this gas comes from is not immediately clear, but obviously its existence must be taken into account in considerations of the energetics of clusters of galaxies. This step has now been taken by Gull and Northover, and their view may well be the model with which observations of galaxies and quasars during the next few years will be compared.

Gull and Northover are, of course, particularly concerned with the appearance of galaxies in the radio telescope. The characteristic phenomenon here is the structure of the radio galaxies—frequently they consist of a pair of radio sources bracketing the optical galaxy. This dumb-bell shape is assumed to have been formed as a result of repeated explosions in the galactic nucleus.

What Gull and Northover have done is to examine what the effect of the intergalactic medium would be on the material thrown out in these galactic explosions. It turns out that the pair of radio sources can be interpreted as bubbles of material moving out into the intergalactic medium from their point of origin in the galaxy. In other words, Gull and Northover start with the proposition that bubbles of very hot plasma are generated in the nuclei of these galaxies by some mechanism which at present remains unknown. The crucial point then is that as this gas is less dense than the intergalactic medium, the bubble will rise, as it were, through the medium like a bubble of gas in water.

Much can be done by considering the balance between the internal pressure in the bubble and the external gas pressure, and by examining the theory of the way in which bubbles rise under gravity in a fluid. Gull and Northover have done these calculations, and come to the conclusion that there is no problem in containing even the most intense radio sources. By involving the intergalactic medium their description also allows an explanation of why there should be two and only two radio sources situated on either side of the nucleus.

This ticklish question is tackled from a consideration of the motion of the bubbles once they have left the nucleus. It seems that each bubble will develop into a nearly spherical cap followed by a highly turbulent wake. This wake is likely to disrupt any bubbles following immediately behind the initial two bubbles. And as Gull and Northover explain, there are reasons for supposing that the plasma released by a series of explosions in a galactic nucleus will not expand uniformly from the nucleus, but instead will expand preferentially along the rotation axis, forming an elongated cavity which eventually collapses in the middle into two separate bubbles.

This model is already reasonably successful in accounting for several features of radio galaxies—for example, the region of weak radio emission between the two chief sources is interpreted as originating from the wake, and Gull and Northover also predict various correlations between the size and power of the radio sources and the properties of the associated galaxy and galactic cluster. This aspect of their work will no doubt be the first to come under examination. But if this examination turns up no important snags it is likely that this model will be the yardstick against which radio observations of many extragalactic objects will be tested for the next year or so.