ties of elliptical galaxies (if not quasars!) and more advanced N-body calculations are the obvious means whereby both observational astronomers and theoreticians can contribute to its further development.

COMA CLUSTER

Missing Mass still a Problem

from our Observatories Correspondent

G. and A. de Vaucouleurs of the McDonald Observatory (University of Texas) have reported the results of a search for luminous matter between galaxies in the Coma cluster (*Astrophys. Lett.*, **3**, 219; 1970). Coma is one of the best examples of a cluster in which there is a "missing mass" problem. Measurements of the redshifts and projected separations of member galaxies have been used to infer the mass of the cluster through the virial theorem. This assumes, of course, that the cluster is a stable, self-gravitating system. The mass obtained from the virial theorem is about 7×10^{14} Suns, while the total mass of the visible galaxies is estimated to be about a factor of five less than this. Discrepancies of this kind are commonly found in clusters of galaxies. But whereas most clusters of galaxies appear as loose aggregates with little central condensation, the Coma cluster is a radially symmetrical, centrally condensed object which certainly looks to be in equilibrium.

There are several possible forms for the missing mass: intergalactic stars, neutral hydrogen, ionized hydrogen, molecular hydrogen and "black holes" have all been suggested. Some of these have already been ruled out. For example, neutral hydrogen in sufficient quantity would have been detected by its 21 cm emission, and ionized hydrogen hotter than a million degrees would produce detectable X-rays.

The de Vaucouleurs searched for luminous matter—emitting gas or intergalactic stars—by scanning across a diameter of the cluster, which is about a degree across, with a sensitive pulse-counting photometer. They determined the mean sky background well away from the cluster and found that in blue light this was equivalent to one star of magnitude 22·3 every square second of arc. This background is mostly due to terrestrial airglow rather than to the integrated luminosity of faint stars and galaxies. A small excess luminosity extending over 30–45 minutes of arc centred near the geometrical centre of the cluster was detected. The peak of this excess brightness was only 26·2 magnitudes/s^2. The overall "intergalactic" luminosity amounted to 40 per cent of the accepted value for the integrated luminosity of cluster galaxies, however.

This excess luminosity is not interpreted as being truly intergalactic (due to stars which are not bound to any particular galaxy). Instead, the de Vaucouleurs conclude that it can be substantially accounted for by the overlapping coronas of the two supergiant elliptical galaxies, NGC 4874 and NGC 4889, which lie at the centre of the cluster, and a few others. Measuring the total luminosity of a galaxy is a long standing problem in astronomy. As Hubble found, the luminosity per unit area goes down almost as the square of the radius in the outer parts of a galaxy, so that it merges imperceptibly into the background sky with a still substantial contribution coming from the outer parts. The de Vaucouleurs estimate the effect of the corona of NGC 4889 by comparing the luminosity profile of its inner parts with that of the nearby, isolated, supergiant elliptical, M 87. The luminosity profiles agree when suitable allowance is made for the different distances of the two galaxies. Recent work by Arp and Bertola, and by G. de Vaucouleurs, on M 87 itself showed that this galaxy, which on photographs has an apparent diameter of less than 4 minutes of arc, is in fact at least a degree across. Others had used sky comparison areas about 30 minutes of arc away from M 87 and the revised measurements raised its total luminosity by half a magnitude. The de Vaucouleurs' measurements of the Coma cluster led them to increase the luminosities of the two supergiant galaxies in the Coma cluster by the same factor.

The upward revision by 40 per cent of the total light from galaxies in the Coma cluster does little to relieve the "missing mass" problem. The mass-to-light ratio required to bind the cluster is still about 200 solar units. For normal elliptical galaxies with mass and light distributions that have been measured, this number does not exceed about 50.

ISLAND MOVEMENT

Dissent on Madagascar

from our Geomagnetism Correspondent

THE assertion by Strong and Flower (*Earth Planet. Sci. Lett.*, **7**, 47; 1969) that Madagascar has been in its present position relative to Africa since the late Carboniferous, and probably since the Pre-Cambrian, has been strongly criticized by Wright and McCurry (*Earth Planet. Sci. Lett.*, **8**, 2671; 1970). Strong and Flower based their conclusion on the existence of sandstone inclusions in some of the lava flows on the Comores Archipelago which separates the Mozambique Channel from the Somali Basin (see map, *Nature*, **225**, 11; 1970). This, they claimed, provides "unequivocal evidence that this part of the Indian Ocean is underlain by non-oceanic crust".

Wright and McCurry disagree with this. They suggest that slightly metamorphosed sandstone inclusions in basalts of the Comores Archipelago are evidence only that beneath some of the volcanoes there are arenaceous sediments, fragments of which have been carried to the surface and baked by the ascending lavas. In short, they feel Strong and Flower draw too strong a conclusion. They agree that the evidence against a southward movement of Madagascar, in particular the fact that the sense of displacement (sinistral) along fracture zones in this area of the Indian Ocean is in the wrong direction, is too strong to be denied—but disagree that the island has thus stayed put. They point out that a case may still be made for an older proposal that Madagascar followed India and the Seychelles north-eastwards, having originally occupied the Inhambane delta region north of Lourenço Marques. Although this interpretation conflicts with some of the geological evidence, it is consistent with the sense of the transcurrent faulting in the South-West Indian Ocean and yet is not inconsistent with the presence of sandstone inclusions in the Comores lavas. The debate will no doubt continue.