X-ray Sources in Cluster of Galaxies

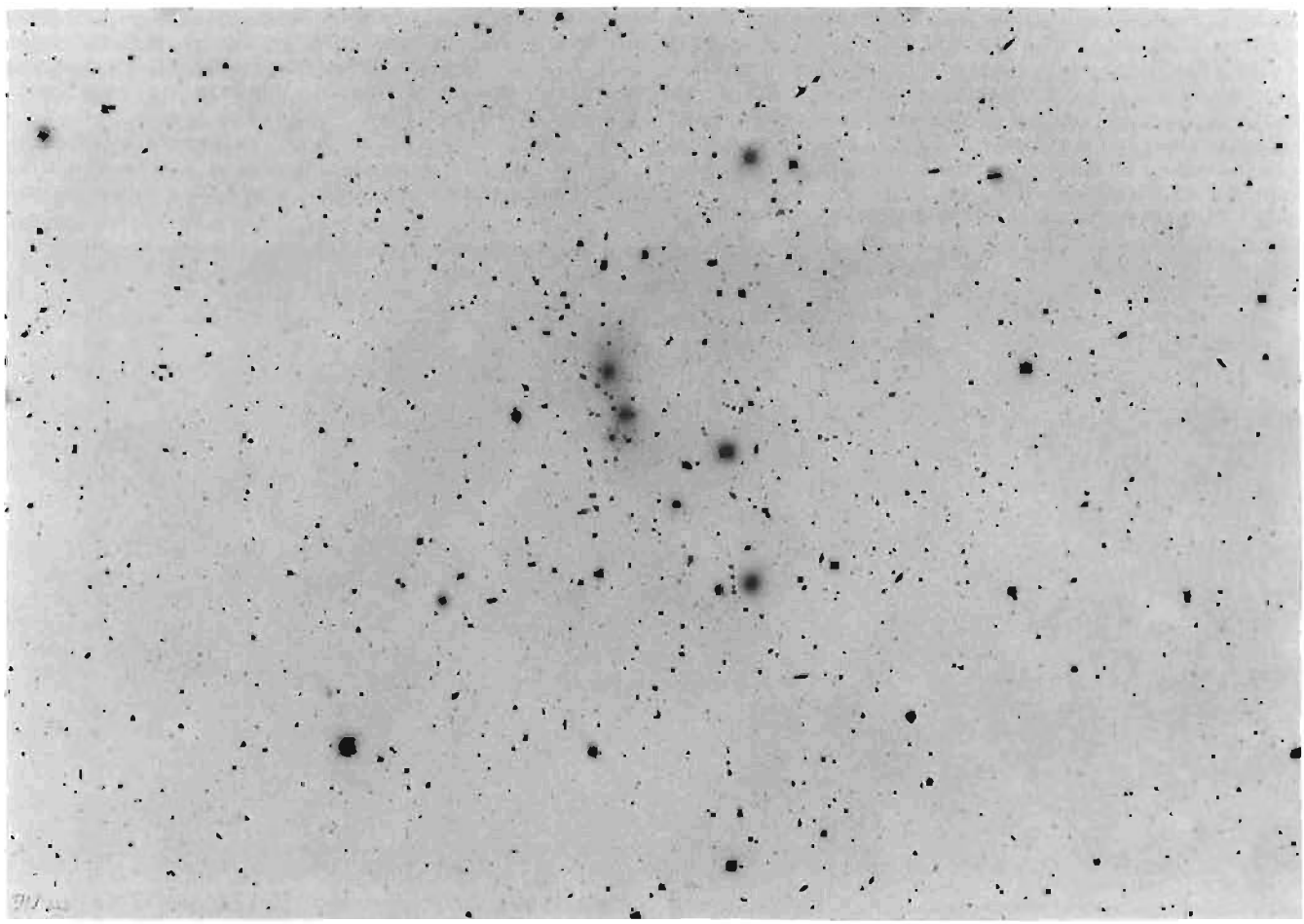
Dr. R. Havlen (ESO staff astronomer in Chile) and Dr. H. Quintana (former ESO fellow in Geneva, now with NRAO, Charlottesville, Virginia, USA) recently undertook a thorough study of the southern X-ray cluster of galaxies CA 0340 – 538. Ever since satellites with sensitive X-ray detectors first showed the presence of strong X-ray sources near the centres of rich clusters of galaxies, astronomers have been asking: why and how? Some even think that high-energy astrophysics has never had as fascinating a subject for study as the central regions of X-ray clusters. Here, as in any other field of astronomy, observations are of paramount importance. Drs. Havlen and Quintana introduce the new field and explain their programme:

The general concepts and questions concerning clusters of galaxies were discussed in the September 1976 issue (No. 6) by Dr. Jürgen Materne. Here, we want to summarize one aspect of clusters of galaxies, i.e. the X-ray emission by some of them, and briefly describe one interesting example being studied at ESO.

Rich clusters of galaxies, typically containing up to thousands of members, are often observed as powerful emitters of X-rays by the various satellites now devoted to X-ray astronomy. Some other extragalactic objects are also observed in X-rays. Some QSOs, Seyfert galaxies and other active objects are detected, but all of them appear to be compact and sometimes variable. Cluster X-ray sources have an appreciable size, being one or two million light-years in diameter. It is conjectured that the X-ray radiation in these sources is nothing else but the thermal radiation of a very hot, tenuous gas (at a temperature of a hundred million degrees) that would fill the inner regions of the clusters, being invisible on photographic plates. It is an open question at this time as to what would be the origin of such a gas. Would it be the remnant of the primordial, unprocessed, material of the Universe, i.e. a mixture of hydrogen and helium only? Or would it be material coming out of the galaxies themselves or some combination of these two possibilities?

Since the mass present in gas is not bigger than the mass in the galaxies, none of the above possibilities is excluded a priori. If this question is answered, there remains the problem of what is the heating mechanism in operation. The possible detection of iron lines in the X-ray spectrum of the Perseus cluster very recently by the Ariel satellite would indicate the presence of material originating in the galaxies, if confirmed. At least part of the gas would have been processed in stars that produce the metals.

Due to the limited sensitivity of the detectors in X-ray satellites, only one or two dozen cluster sources have been



Central region of the cluster CA 0340 – 538. Deep IIIa-J plate taken in the prime focus of the 4-metre telescope at the Cerro Tololo Inter-american Observatory by Dr. J. Graham. Note the three giant elliptical galaxies.

detected. It is important to identify these sources to study the optical clusters in detail. In 1958, George Abell compiled a catalogue of all the rich clusters (down to a certain magnitude) that appear on the Palomar Sky Survey, i.e. in the northern hemisphere to $\delta \simeq -20°$. This list has helped astronomers to identify X-ray clusters in that area of the sky, but in the south this task has been rather slow. With the ESO/SRC sky survey in progress, today the job is easier.

Plate collections of the southern skies were searched for X-ray cluster identifications. One of them was the proper-motion plate collection of the University of Chile taken with the Maksutov camera at Cerro El Roble between 1968 and 1973. On positional agreement (sometimes rather poor because the X-ray error boxes were big) some identifications were suggested based on this material and the 3 UHURU catalogue of X-ray sources (Jorge Melnick and Hernan Quintana, *Astrophysical Journal* 198, L 97, 1975).

The Ariel 5 satellite has recently confirmed one of the suggested interpretations (J. P. Pye and B. A. Cooke: *Monthly Notices* 177, 21 P, 1976). The source 3U 0328 – 52 lies within an area of 18 square degrees that includes three rich clusters of galaxies, but one of them appears as the likely source because of morphological reasons. The source detected by Ariel 5 has a much more precise position and coincides with the proposed cluster: CA 0340 – 538. This fairly spherical cluster contains many hundreds of galaxies, mostly ellipticals concentrated towards the centre, and has three giant ellipticals which show extended halos. Previous examples of such galaxies in clusters appear isolated or in pairs (see photo of the cluster).

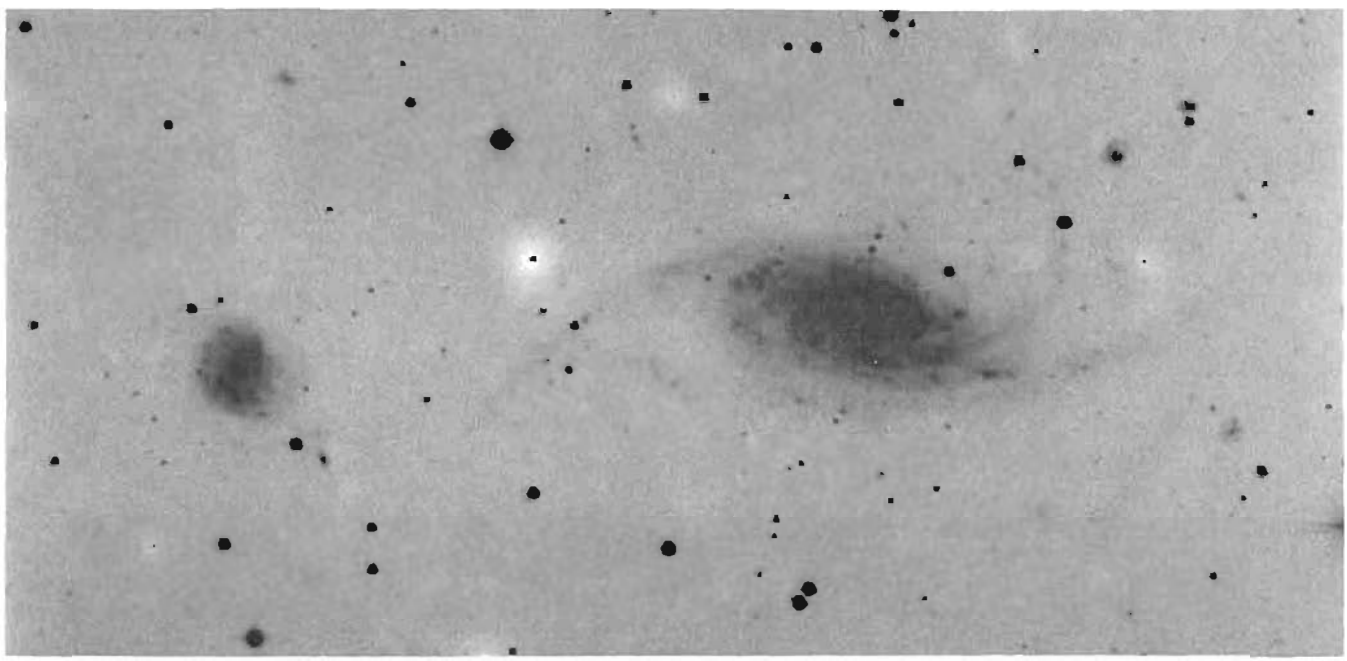
A programme was started at ESO to study this interesting cluster. Radial velocities have been determined for a number of galaxies using the 152-cm telescope. In this way a velocity dispersion can be estimated. A photometric study is in progress, comprising both photoelectric photometry and measures of direct plates using the PDS densitometer at the Nice Observatory. Also, a study of the morphology and distribution of the various galaxy types throughout the cluster is being carried out from plates taken with the ESO Schmidt telescope at La Silla. All this information, when combined with the X-ray data, is expected to restrict the types of models that can be constructed to explain the origin of the intracluster gas and its heating mechanism. Because the answer will bear on the evolutionary history of the clusters and their formation, one hopes to approach a solution to the problem of the "missing mass".

Spectroscopic Observations of Galaxies in the ESO/Uppsala Lists

In the June 1976 issue of THE MESSENGER (No. 5, p. 5), we reported on the joint ESO/Uppsala programme, the aim of which is to establish a catalogue of conspicuous objects on the ESO (B) plates. Since that time good progress has been made and about 300 fields (or half of the ESO (B) Atlas) have now been searched. Approximately 9,000 objects have been listed; just recently, the fourth ESO/Uppsala list was published in the *Astronomy & Astrophysics Supplement Series* (Holmberg *et al.*, 27, 295).

There is no doubt that many southern astronomers have already made efficient use of these lists as a basis for their observing programmes. In the southernmost fields, more than 70 % of the listed objects are new. Most are galaxies and a large number of potentially "interesting" ones (interacting, peculiar, etc.) are found in the lists.

In order to exploit optimally this extremely "rich" material, a systematic approach is desirable. In addition to American astronomers at the Cerro Tololo Interamerican



Interacting system ESO 122-IG01/IG02. On this photo, obtained with the ESO 3.6-metre telescope on November 24, 1977, one may clearly see a "bridge" connecting the larger galaxy (IG01) with the smaller (IG02). The system resembles to some extent the much brighter M51 system. The distance is about 45 Mpc and both components show emission lines. (Plate 110, 90 min exposure, IIIa-J + GG 385; observer Dr. H.-E. Schuster.)