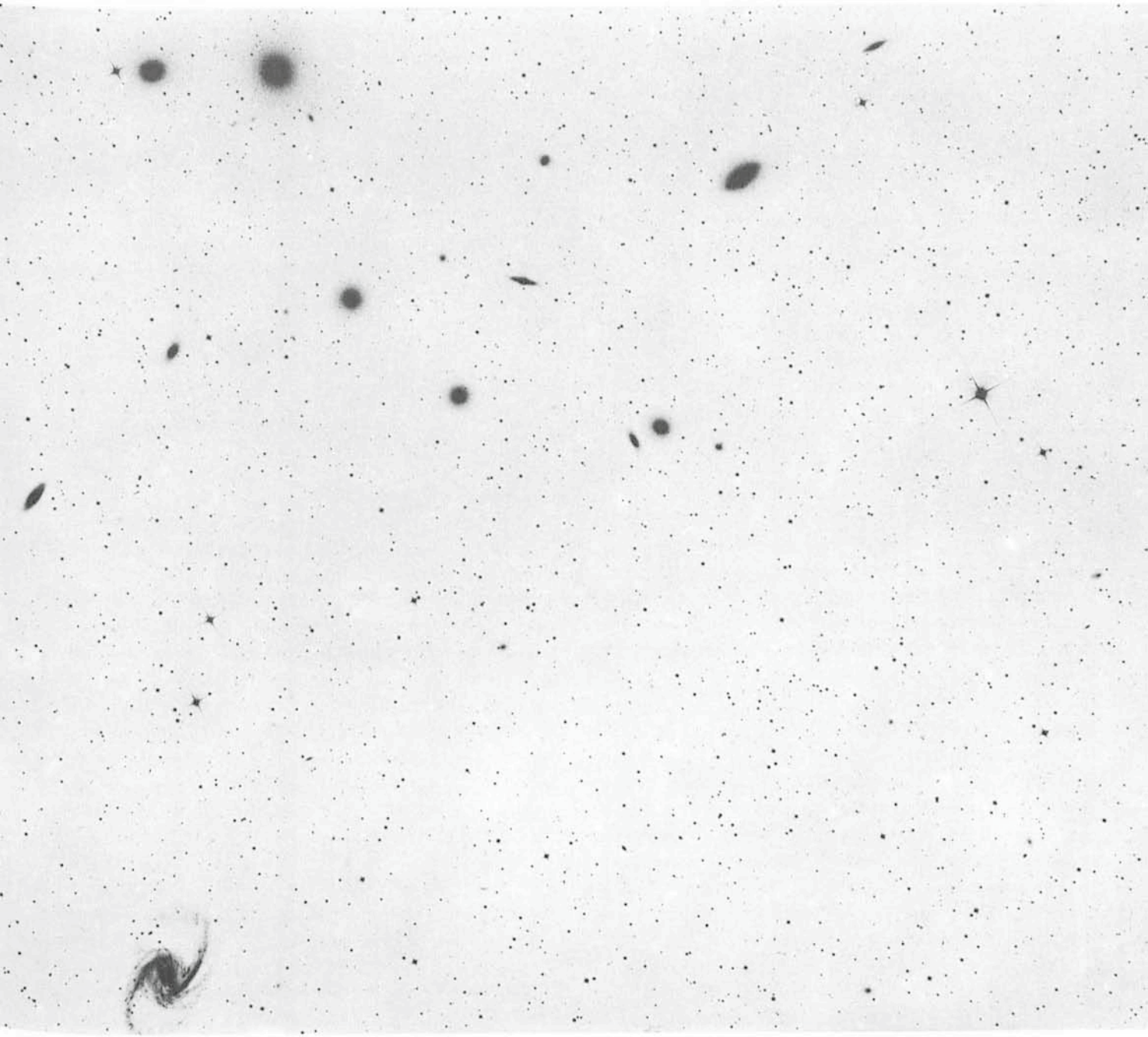
Clusters of Galaxies

Why do galaxies cluster? Are these clusters stable over long periods or will they slowly disperse? Is there "hidden" mass in the galaxy clusters? These problems are central in current astronomical research, and the answers may tell us how the very young universe looked like, some 15,000–20,000 million years ago. Dr. Jürgen Materne from the Hamburg Observatory holds a fellowship with ESO's Scientific Group in Geneva. Here he tells what is being done at ESO in this important field of astronomical research:

The basis of one of the large catalogues of galaxies—the NGC catalogue—was laid by observations by the Herschel family of astronomers, nearly two hundred years ago. In this catalogue, galactic nebulae and extragalactic objects were still mixed, because the astronomers at that time did not know that many of the nebulae were far outside our own galaxy, the Milky Way. Nevertheless, already the Herschels noticed that the nebulae (in our case the galaxies) often formed groups. They detected among others the Virgo and Fornax clusters.



This is the centre of the medium-size Fornax cluster of galaxies, which also contains a strong radio source. The cluster was photographed with the ESO Schmidt telescope. The beautiful bright spiral galaxy with the pronounced bar is NGC 1365. At least twenty-five other galaxies may be seen in this photo.

Groups and Clusters

The difference between groups and clusters seems to be artificial, it is a question of richness: a *group* mostly contains from a couple to a few dozen galaxies, a *cluster* may have from around fifty members like the Fornax cluster to ten thousand like the Coma cluster. In addition to these, we have so-called "solar system"-like groups, a large galaxy with a few dwarf companions. Our Milky Way is a fairly large galaxy and has several such small companions: e.g. the Sculptor, the Draco and the Ursa Major galaxies. The clustering over all sizes is amazing and is not at all explained by the current theories of galaxy formation.

With all these different sizes, a few questions arise at once:

(1) Do the clusters show substructure, or

(2) do clusters of galaxies form superclusters, and

(3) do *real* field galaxies exist, i.e. galaxies which do not belong to any cluster of galaxies?

Superclusters?

The French-American astronomer de Vaucouleurs claims that the nearby groups of galaxies, including the Local Group to which our Milky Way belongs, are contained in the *Local Supercluster* with the Virgo cluster at the centre. But this ist questioned by other astronomers who say that the Local Supercluster is only a chance configuration in the sky. Chincarini and Rood recently found a companion cluster of galaxies to the Coma cluster. These two (and others?) may form a supercluster. On the other hand, the application of the mathematical tools of cluster analysis which we are developing at ESO, shows that the Fornax cluster for example tends to break down into relatively well-defined subclusters, although it is not completely clear at the moment how significant these subclusters are. And the problem whether the spiral galaxies and the elliptical galaxies in the Virgo cluster form different subsets is not solved either.

Field Galaxies

Only very few field galaxies have been detected but it is always difficult to be sure if they do not belong to a nearby cluster with high internal velocity dispersion. And it is nearly impossible to find out whether seemingly single galaxies do not form small clusters with dwarf galaxies (to build what is called *Hyper-galaxies* by Estonian astronomer J. Einasto), because these dwarf galaxies are too faint to be observed.

Although the problems of how to define a cluster of galaxies correctly and how to assign the proper membership of individual galaxies are not solved, astronomers try to look for differences in the contents of different clusters. Rich and dense clusters contain mostly elliptical galaxies and sometimes a *supergiant* elliptical galaxy with a large halo in the centre of the cluster. A programme is now underway at ESO to measure the internal velocity dispersion of such supergiant galaxies in order to deduce their masses and to confirm if they are really, as some astronomers surmise, one hundred times more massive than normal elliptical galaxies. Irregular and loose clusters, on the other hand, have a large fraction of spiral galaxies and it seems that the hydrogen content in the spiral galaxies depends on the type of the surrounding cluster.

Missing Mass?

The correct membership assignment is also vital for calculating the mass of clusters of galaxies and for investigating the dynamical state of a cluster. Often one finds that the sum of the masses of its member galaxies, i.e. the "visible" cluster mass, is not enough to make the cluster gravitationally stable, to keep it from falling apart. Is there a hidden, "invisible" mass, perhaps as an intra-cluster medium? But neutral hydrogen has not yet been found in large amounts, so Materne and Crane started collaborations with radio astronomers to look more carefully for hydrogen in small clusters. In rich clusters, however, X-ray radiation has been detected. That means that some clusters are filled with a very hot gas, but unfortunately the amount does not seem to be enough to keep the cluster together.

The ESO Programme

In order to tackle some of these problems we start this winter at ESO a programme to measure the radial velocities of galaxies in the region of the Eridanus, Fornax and Doradus clusters as well as possible.These velocities must be measured with high precision, because the subgroups have only a velocity dispersion of around 40 km/sec. Then we can test and refine our new models of clusters. We shall also try to detect the hot gas in the optical region by measuring the Hβ emission with a modified photometer. In a long-range programme in collaboration with other institutes, we shall determine the velocity distribution and the distribution of galaxy types and luminosities in X-ray clusters and non-X-ray clusters. We think that all these observations will give us a better insight into the phenomenon of galaxy clustering.

Tentative Meeting Schedule

The following dates and locations have been reserved for meetings of the ESO Council and Committees:

October 26	Instrumentation Committee, Garching
October 28	Committee of Council, Garching
November 25/26	Observing Programmes Committee, Amsterdam
Nov. 30/Dec. 1	Finance Committee, Garching
December 2/3	Council, Munich