The Mysterious Elliptical Galaxies

F. Bertola

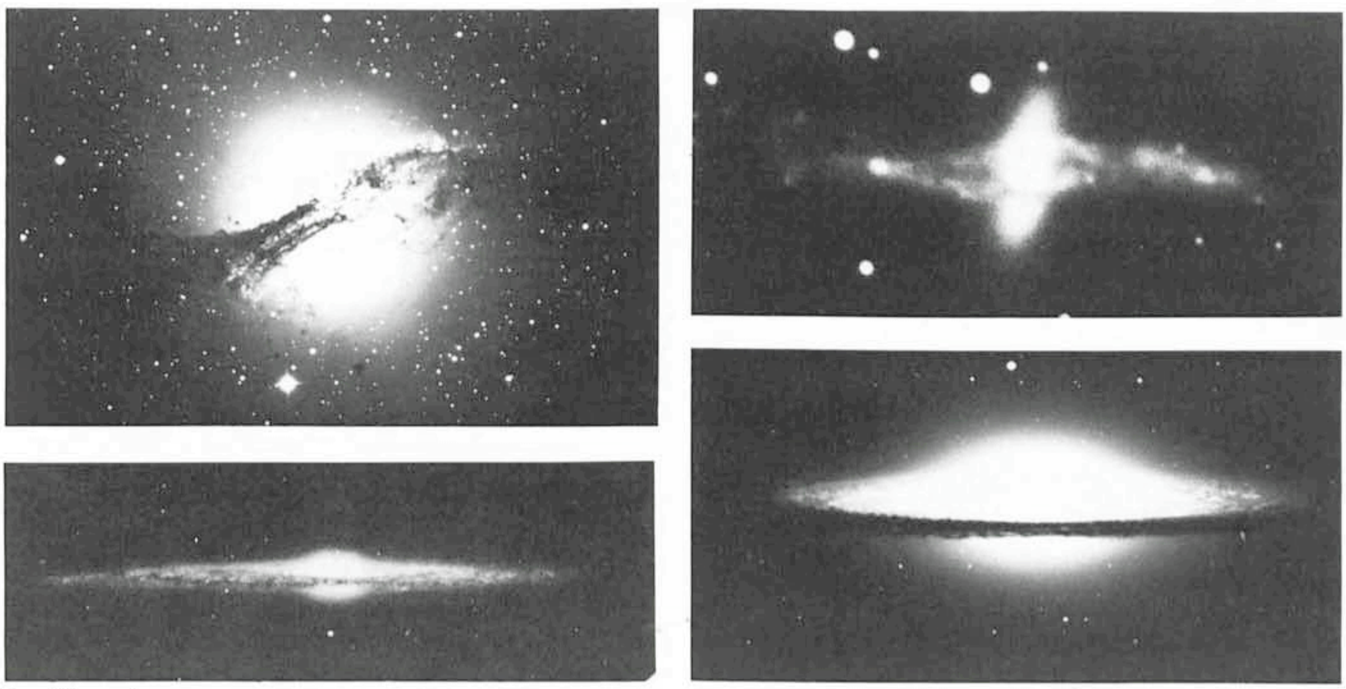
Until recently, most astronomers agreed that the elliptical galaxies were very well understood. Then, a few years ago, evidence was found that their ellipsoidal shapes cannot be explained as a flattening by rotation alone. Some even seemed to be prolate, i.e. extended in the direction of the poles! This problem, of cosmological significance, has been studied by Dr. Francesco Bertola at the Astronomical Institute of the Padova University (Italy) and his collaborators. Needless to say, one of the problems he would like to investigate with the VLT concerns these strange galaxies.

My approach in preparing a programme for ten nights of observations with the 25 m VLT telescope consists in considering the limitations I am facing in my current research which is carried out with the largest telescopes presently available. The main constraints are now spatial and spectral resolution and the detection of faint signals against the sky background. Hopefully, the very large collecting power of the VLT, coupled with up-to-date auxiliary equipment and sophisticated data-processing techniques will contribute to overcome at least part of the present limitations. The observing programmes I am proposing reflect my current interest, but they take advantage of the high performance of the VLT.

The Shapes of Elliptical Galaxies

A very large fraction of the observing time will be devoted to the study of the structure and dynamics of elliptical galaxies. During recent years several observations have led to a dramatic change in our view of elliptical galaxies. The unexpected, very low velocity of rotation that is found even in apparently flat systems (Bertola and Capaccioli, 1975, Illingworth, 1977) as compared with the velocity dispersion, has contradicted the previous theoretical models, attributing the flattening to rotation only.

More complicated models suggesting a triaxial or prolate configuration have been proposed for elliptical galaxies. An important aim of future observations should be to provide evidence in favour or against them. Detailed surface photometry of elliptical galaxies with high spatial resolution will allow the study of phenomena like the twisting of the major axis of the isophotes and the variation of their ellipticity in the innermost parts. These phenomena could be related to a triaxial structure, but their presence is not a necessary condition for such a structure, because of the dependence on projection effects. Consequently, the nature of this study is somewhat statistical and requires observations of a large number of galaxies.



Possible prolate structures in the galaxies NGC 5128 (upper left) and NGC 4650A (upper right) as compared with an oblate spheroidal component superimposed on a disk in normal galaxies NGC 4565 (lower left) and NGC 4594 (lower right). NGC 5128, 4650A and 4594 were reproduced from 3.6 m photos (observer Dr. S. Laustsen) and NGC 4565 was photographed with the Palomar 5 m telescope.

The VLT will be able to observe the galaxies of the Coma and Perseus Clusters in the same detail as today's instruments observe the Virgo Cluster. In order to get a complete picture of elliptical galaxies, the photometric study has to be coupled with detailed dynamical analysis. The large scale of the telescope and sophisticated detectors covering the whole image of the galaxy will allow complete mapping of the velocity field and velocity dispersion, and thus provide a way to discriminate between different models. Triaxial models, for instance, do not require zero velocity gradient along the apparent minor axis, as in the oblate case.

All these observations require high spectral resolution. Since we already know the very peculiar behaviour of the luminosity profile and of the velocity dispersion in the nucleus of M 87 (Sargent et al., 1978) a proposal entitled: "A search for black holes in the nuclei of elliptical galaxies" seems to be a very appropriate one for the VLT, particularly if black holes continue to be fashionable as they are now.

Interesting cases to be studied are the elliptical-like galaxies which are rich in dust and gas, often radio sources, which Bertola and Galletta (1978) have recently proposed to possess a prolate configuration (i.e. extended in the direction of the poles). Unfortunately there is only one galaxy of this kind, namely NGC 5128, which is close enough to be studied in detail with present telescopes. In order to understand the way in which these galaxies formed and their correlation with other types of galaxies, it is of great interest to study both the dynamics of the gas and of the stellar component.

Stars in Elliptical Galaxies

Finally, being always confined to elliptical galaxies, a "Study of the stellar population in the nuclei of elliptical galaxies" would be another programme requiring high spatial and spectral resolution. We are at the present moment collecting some evidence that the stellar content in the nuclear parts of ellipticals could differ drastically from the rest of the galaxy. Very recent observations (Bertola and Capaccioli, 1979) in the UV show that in the nucleus of the giant elliptical galaxy M 87 the energy distribution is increasing towards short wavelengths as a black body with a temperature of 30,000°K. The interesting fact is that the phenomenon is not just concerning the stellar-like, central source in M 87, but the whole innermost nuclear region, indicating a peculiar stellar population in the nucleus of M 87. Is this phenomenon characteristic of active galaxies only? Is star formation occurring in the nuclear regions of the ellipticals? This is an example of the questions that detailed spectrophotometric studies carried out with the VLT could answer.

There is of course the possibility, which is highly desirable, that at the time the VLT enters into operation, most of the problems envisaged in this article have already obtained a satisfactory explanation. But in the meantime, new and perhaps even more complicated problems will have arisen and the VLT will be a powerful tool for solving them.

References

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The VLT and the Infrared

J. Borgman

The use of the VLT will not be restricted to the visual region of the spectrum. One of the great advantages of the large size will be the greatly improved angular resolution in the infrared. Professor Jan Borgman of the Groningen University (of which he is Rector) has since long been active in infrared astronomy. He explains how the VLT can be used to study cool objects and possibly contribute actively to the search for life in the Milky Way.

Larger telescopes have more light-gathering power and can do some jobs of smaller telescopes in less time. In the same observing time a 25-m dish will reach 3.5 magnitudes deeper than the 200-inch, as long as background saturation can be ignored. Such merits of large dishes are obvious; undoubtedly some time on the VLT will be given to programmes which have to push the limiting magnitude in order to reach more distant and/or fainter stars.

However, I would expect that the Observing Programmes Committee would favour proposals which really require the use of the VLT and which have contributed to the justification of the initial investment. In this class are some applications of the angular resolution capabilities of the VLT in the infrared, which can be favourably exploited with an infrared camera.

Infrared Cameras

With available techniques an infrared camera picture has to be synthesized from observations with arrays of a modest number of discrete detectors. However, it is certain that the future will offer multiple element targets with high resolution capability. The VLT has diffraction-limited images of 0.2 arcseconds at the 10 μm diffraction limit in a field of 10 x 10 $arcmin^2$ (reasonably assuming that a fully corrected field of 15 arcmin diameter is available). We need 10^7 picture elements in order to get diffraction-limited resolution over this