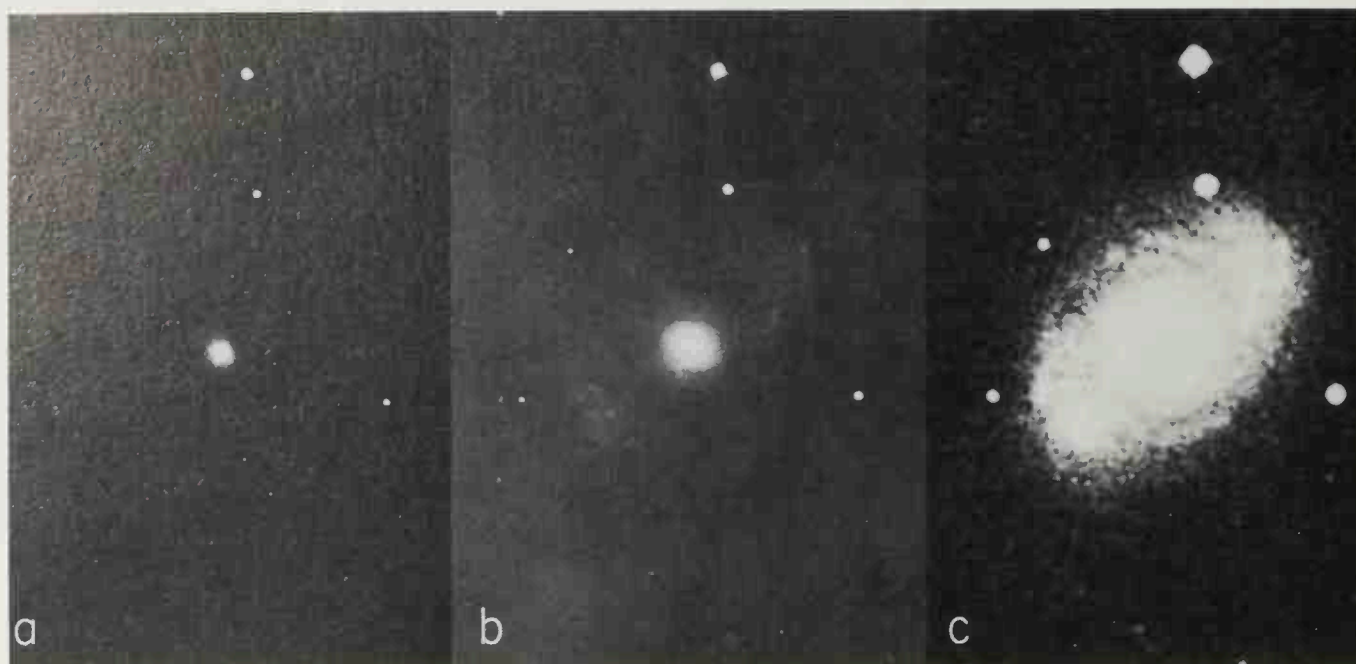


The Seyfert galaxy NGC 4151 in three photographs on the same scale but with different exposures. In (a) only the star-like nucleus is seen (making it look like a quasar); outer spiral structure is seen faintly in (b) and strongly in (c).



discuss shortly. Most Seyfert galaxies radiate strongly in both the infrared and the ultraviolet, but although all emit radio waves more strongly than ordinary galaxies only a few are very strong radio sources. Several Class 1 Seyferts have been identified as very strong X-ray sources.

It is just possible that Class 2, the less extreme type, could generate their radiation using only normal thermal processes, if the nucleus contains a very large number of hot stars and a large amount of interstellar dust, which could produce the excessive quantities of ultraviolet and infrared radiation observed. It is certain, however, that Class 1 Seyferts could not be explained in this way.

Almost all Seyferts appear to be S or SB galaxies with active nuclei, and it is estimated that about 1 per cent of all spiral galaxies are Seyferts.

N-type galaxies

The N galaxies are basically similar to Class 1 Seyferts but the nuclei are relatively brighter and more compact and the surrounding galaxy is less clear; both have redshifts rather larger than those for ordinary galaxies. N galaxies were identified as a separate optical class by William Morgan in 1958, and came to be studied particularly in the 1960s when optical surveys were made of radio sources. This clearly influences the fact that very many of those known are strong radio sources, by a process of observational selection.

Markarian galaxies

An extensive survey of galaxies which are bright in the ultraviolet has been carried out since 1967 by B. E. Markarian at the Byurakan Observatory in Armenia. His lists so far contain about 700 objects, of which about 10 per cent are Seyfert galaxies; indeed, it is through his work that most known Seyferts have been discovered.

Markarian galaxies are of two major types, one where the ultraviolet emission is from a bright nucleus, and the other where it comes from the whole galaxy. The galaxies with bright nuclei include

the Seyferts but most are of a new type; they appear to have an excess of hot stars in the nucleus, which causes the emission of narrow spectral lines. There is also a variety of other objects, ranging in size down to small dwarf galaxies which, unlike dwarf ellipticals, have strong ultraviolet radiation, and so must contain very young, hot stars and ionized gas. They are essentially what could be called intergalactic H II regions.

Compact galaxies

Starting in the 1930s, Fritz Zwicky prepared lists of objects appearing in the Palomar Sky Survey photographs which are only just distinguishable from stars there, and called them **compact galaxies**. They include objects now known to be at very different distances: a few of them are probably nearby 'intergalactic H II region' dwarf galaxies; many, however, appear to be ordinary galaxies seen very far away; while some are N- and Seyfert-type objects, resembling quasars.

Quasars

A quasar or QSO (quasi-stellar object) is defined as a starlike object whose optical spectrum contains bright emission lines with large redshift, although marginal cases, such as 3C 48 which has weak nebulosity or 3C 273 with a jet feature, are not excluded. (Both of these objects are now known to be surrounded by considerable nebulosity in the form of an associated galaxy.) Usually the optical light varies irregularly over a time scale of months, there is strong ultraviolet radiation, the emission lines are broad, and often there are also narrower absorption lines. Many quasars are identified with strong radio sources, often with radio components of very small angular size. A radio-strong quasar is denoted by QSS (quasi-stellar source). The intense ultraviolet radiation or the strong emission lines are used in searching for new quasars, particularly those which are radio-quiet.

Although the first identification of a radio source with a starlike object was in 1960, it was three years