ENGINEERING
AND SCIENCE
June 1965, Vol. XXVIII, No. 9

INTERLOPERS IN SPACE

New findings may make it possible to determine the structure of the universe

Allan Sandage, staff member of the Mount Wilson and Palomar Observatories, has discovered a new class of astronomical objects that may make it possible, within a short time, to determine the structure of the universe.

For the past 20 years many of these objects were thought to be blue stars in the outer regions of our Milky Way Galaxy. Now they are suspected of being very distant super-bright galaxies reaching more than halfway to the horizon of the universe. Dr. Sandage has tentatively named them "quasi-stellar blue galaxies." Although they are related to the quasi-stellar radio sources, they do not emit radio energy. They may represent the next evolutionary step after the quasi-stellar radio sources. They may also be galaxies in the process of being born.

The new objects are like the quasi-stellar radio sources in that they appear to be up to 100 times brighter than an ordinary galaxy. But they are 500 times more numerous than the radio sources. There are probably more than 100,000 of them down to 19th apparent magnitude, which is the limit of the magnitude at which objects can be seen by the Schmidt telescope at Palomar. (The 200-inch telescope sees objects 40 times fainter.)

The major significance of the Sandage discovery is that astronomers now have a powerful new tool which can probe enormous distances into the cosmos to test the "big bang" versus the steady state model of the universe.

The "big bang" theory holds that some 12 billion years ago all the matter in the universe was in one place and was ejected outward in every direction by a gigantic explosion. The matter, now condensed into stars and galaxies, continues to move along the same paths. According to the steady state theory, matter is continually being formed and the universe has no beginning and no ending.

"The quasi-stellar galaxies appear to be so numerous and reach so far into space," says Dr. Sandage, "that we should be able to determine the effects of space curvature and the slowing down of the expansion of the universe within the next few years."

Clues to the true model of the universe already are emerging from the studies made by Dr. Maarten Schmidt and Dr. Sandage of the much less numerous quasi-stellar radio sources ("Extending the Frontiers of Space" – *E & S, May 1965*).

The clues suggest that our universe is a finite, closed system which originated in a "big bang," that the expanding universe is slowing down, and that it probably pulsates perhaps once every 82 billion years. The evidence is inconsistent with the steady

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state theory. However, there is not yet enough evidence for conclusive determination of the true model of the universe. The existing evidence is based on the red shifts and light measurements of only nine quasi-stellar radio sources, and the light measurements of a few quasi-stellar blue galaxies.

"With these sources we already are looking out slightly less than halfway to the observable horizon on the model of the universe which is emerging from the data," says Dr. Sandage.

"We have every belief that with the much greater red shifts which we expect to obtain, we will see more than 60 percent of the distance to the horizon. Such a distance would encompass one-third of the volume of the visible universe."

Evolution of galaxies

In addition to their importance in solving the long-standing cosmological problem of space curvature and the age of the cosmos, the new class of objects is expected to shed light on the process of formation and evolution of the galaxies themselves. While the discovery is still too new to explain their role in the birth processes of the stellar systems, first indications suggest that astronomers may be seeing galaxies in the very early phases of their life.

Drs. Sandage and Schmidt have obtained spectral red shifts for three of the quasi-stellar blue galaxies, using the spectral line pattern search method developed by Dr. Schmidt for the quasi-stellar radio sources. The red shift for one of the quasi-stellar blue galaxies, named BSO No. 1 (BSO for blue stellar objects), indicates a recession rate of 125,000 miles per second. This makes it the second most distant object known – second only to the quasi-stellar radio source 3C-9, which has a recession rate of 149,000 miles a second.

The red shifts of the two other quasi-stellar blue galaxies indicate that their recession rates are 16,000 miles a second and 24,000 miles a second.

The astronomers found spectral lines of carbon III and IV in BSO No. 1. These are ionized carbon atoms and their spectral fingerprints had been detected previously only in the most distant of the quasi-stellar radio sources. In the two nearer quasi-stellar blue galaxies were found spectral emission lines of oxygen II and III, neon III and V, plus several hydrogen lines.

The red shifts were determined after Dr. Sandage had predicted that the objects would be extragalactic. He and Philippe Veron, a research student from France, located some of the first members of the class while making a survey at Palomar for quasi-stellar radio sources. The two astronomers photographed several faint blue objects that, like quasi-stellar radio sources, emitted much light in the ultraviolet, but which, unlike them, had no radio emission. Dr. Sandage called the objects "interlopers." Recent observations showed the interlopers to be the first members of the new class.

Dr. Sandage found that the brightest of the blue objects – those brighter than 14.5 magnitude – were distributed in depth about as expected for normal stars in our galaxy. Most of these objects are stars. However, the blue objects that were fainter than 14.5 were distributed in a different way. They increased in depth much more rapidly than the brighter objects, suggesting that they were extragalactic.

A second difference between the bright and the faint objects was in the measured ultraviolet energy. Precise measurements of colors showed that the faint objects emitted much energy in the ultraviolet. This is contrary to stars but similar to the quasi-stellar radio sources. It also suggests that the faint objects are extragalactic, and this was later proved by the red shift measurements.

Dr. Sandage found that the fainter of the objects with less than a 14.5 magnitude did not increase in number quite as fast as did the less faint ones per volume of space. He explained this as evidence of the predicted curvature of space and the effect of the red shift in the received light. The influence of the gravitational field of all the matter in the universe is believed to cause space to curve.

Life span of the quasi-stellar blue galaxies

Dr. Sandage believes that some quasi-stellar blue galaxies may still be being born. He calculates that they live for some 500,000,000 years. The figure is based on the estimated age of 1,000,000 years for quasi-stellar radio sources, and on a comparison of their frequency with that of the quasi-stellar blue galaxies.

The new objects are scattered throughout the universe, with the nearest of them about 20 million light years from the earth, which is nearby in cosmological terms.

These objects and the quasi-stellar radio sources appear to be distributed so far away that they should enable the 200-inch telescope to look back 93 percent of the time since the birth of the universe.

"If we can go back far enough we will get back to the time of the birth of the normal galaxies," says Dr. Sandage. "And perhaps we can get back to what is known as the particle horizon where matter had not yet had time to congregate into such structures as clouds, quasi-stellars, stars, or galaxies."