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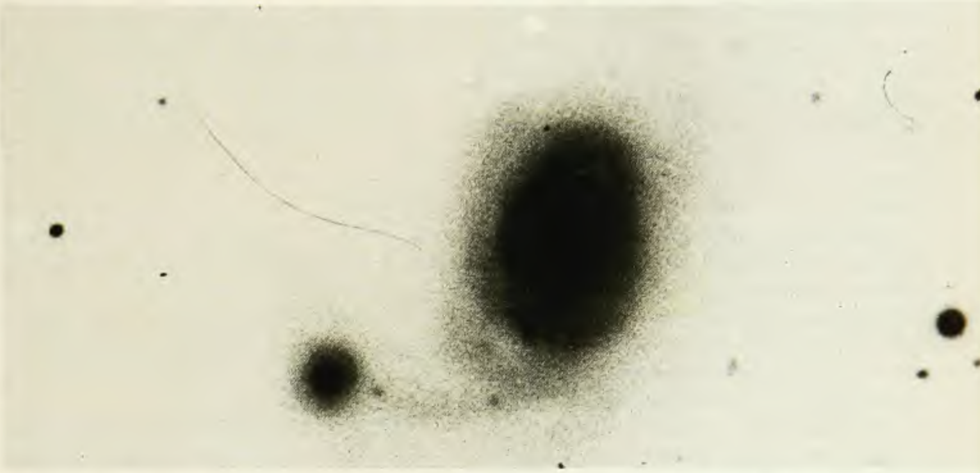
Red-shift problem intensifies, says Burbidge



Galaxy NGC 7603 is connected to smaller companion galaxy by luminous bridge. Companion has red shift almost twice as much as NGC 7603. Halton Arp made the plate.

Since the discovery of quasistellar objects people have debated whether their large redshifts are of cosmological origin or not. Last year a report by Irwin Shapiro and his collaborators implied that quasar 3C 279 was a comparatively local object, while a report by James Gunn suggested that PKS 2251-11 was at a cosmological distance corresponding to a red shift of 0.32 (PHYSICS TODAY, July 1971, page 13).

Over the years Geoffrey Burbidge has been arguing that at least some fraction of the quasistellars have redshifts that may not be of cosmological origin. In a recent interview at the University of California at La Jolla, Burbidge said that the red-shift situation is even more puzzling than before. He feels that we are on the verge of a really major discovery, namely that there are red shifts around that we really don't understand. He seemed delighted at the prospect of using astronomy to discover new laws of physics rather than using the already-understood laws of physics to interpret astronomical results.

In 1964 Jesse Greenstein and Maarten Schmidt (Cal Tech)[1] said that the quasistellar redshift could not be from gravitational effects and hence must arise from recession velocities of objects located at great distances from us in an expanding universe. James Terrell (Los Alamos)[2] argued from their rapid light fluctuations that they must be much smaller than the size of the galaxy and that they might have been all ejected from our own galaxy with velocities corresponding to their observed redshifts. Halton Arp (Hale Observatories)[3] claimed observational evidence that the quasistellar objects were associated with nearby galaxies at distances of 10 to 100 megaparsecs and suggested the redshifts were due to some unknown mechanism. Fred Hoyle (Institute for Theoretical Astronomy, Cambridge) and Burbidge[4] took a balanced position between the cosmological and local hypotheses and discussed local hypotheses that had quasar distances in the range 1 to 10 megaparsecs.

The new puzzlement about red shifts arises from some recent observations of objects with large red shifts that appear close to galaxies on photographs of the sky. The associated galaxy has a much smaller red shift. One explanation offered for such astonishing behavior has been proposed by Hoyle and J. V. Narlikar (Institute for Theoretical Astronomy), who say that the electron mass might be different in each of the two objects. Such a difference in mass would change the Rydberg, thus changing where all the spectral lines would sit.

Arp has found some objects with dif-

continued on page 18

Pion production resembles stripping

Protons from the Uppsala University synchrocyclotron have produced positive pions with angular distributions for (p, π^+), that are quantitatively similar to distributions in the well known deuteron stripping (d, p) reaction. This surprising result, which unexpectedly reinforces the simple view of a proton as a neutron and pion stuck together, comes from the first high-resolution mesic proton-capture experiment involving a change in baryon number.

At the Fourth International Conference on High Energy Physics and Nuclear Structure that took place in September in Dubna, USSR, Bo Höistad described[1] how 185-MeV protons produced ground- and excited-state carbon-13 and beryllium-10 nuclei from carbon-12 and beryllium-9 nuclei, with cross sections strongly dependent on scattering angle. Energy resolution of the proton beam turned out to be high enough that, for carbon, angular distributions for the ground-state peak and three excited-state peaks were determined. Earlier work at CERN[2] with 600-MeV protons had indicated that such reactions occurred, but resolution was not as high.

Höistad and his colleagues, S. Dahlgren, P. Grafström and A. Asberg, used the external proton beam from the synchrocyclotron at the Gustaf Werner Institute in Uppsala to produce pions in the reaction

$$p + {}_zX^A \rightarrow \pi^+ + {}_zX^{A+1}$$

where X is either carbon 12 or beryllium

9.[3] The pions were studied at laboratory angles of 40, 70, 90 and 120 deg for carbon, and at 40 and 90 deg for beryllium. A double-focusing magnetic spectrometer and a system of scintillation counters did the detecting.

In selecting a target, the Uppsala group looked, of course, for suitable threshold energies. But they also wanted relatively wide spacing of ground and low-lying excited states in the expected product nuclei; if the energy-level separation is smaller than the total uncertainty in the absolute proton and pion energy determination, then a peak in the pion-production cross section cannot be reliably identified with a particular level. The energy spread in the 10^{10} proton-per-second beam is less than 0.2 MeV (FWHM), and the carbon-13 and beryllium-10 nuclei have low-lying levels with sufficiently wide spacing to allow identification.[4]

Results for carbon at the various angles show contributions from the ground state of C^{13} as well as from excited levels at, for example, 3.09, 3.85, 6.87 and 9.51 MeV. The observed spectra agree with two types of angular distribution: one that decreases monotonically with increasing angle (that is, with increasing momentum transfer) and another with a minimum at 90 deg. The ground-state angular distribution falls rapidly with increasing angle; the peak between 3 and 4 MeV is apparently symmetric about 90 deg, and so on. These distributions are quite like the angular distributions found for the reaction $C^{12}(d,p)C^{13}$, and theorists have pointed out the similarity between the two reactions.

What kind of model explains the Uppsala observations? Höistad and his colleagues, noting the great momentum-transfer dependence of the cross sections, surmise that the positive pions are produced in a few-particle process (that is, a process such as occurs in direct stripping) rather than as a result of multiple collisions inside the nucleus.

In a pure single-particle process, according to the Uppsala group, the nucleus captures the incident proton into one of its unfilled shells, emitting a pion, whereas in a two-particle process the pion is produced in an interaction between the incident proton and a single nucleon. The relative importance of the one- and two-particle processes might be determined by studying negative pions produced in the reaction $Be^9(p, \pi^-)C^{10}$, because no single-particle process can produce the negative pions, and this experiment is planned. The group also notes that any model for the positive-pion reaction must include some selection rule, because the levels of the residual nuclei are populated unequally.

Höistad stressed that, before more precise calculations of theoretical cross sections can be useful, more experimental information about the reaction mechanism is needed. The Uppsala result may stimulate some novel experiments at those accelerators above the pion-production threshold. —MSR

References

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Redshift *continued from page 17*

fering red shifts that are actually joined with luminous bridges. One such example is NGC 7603 and its companion.[5] One galaxy has a redshift almost twice as much as that of its companion; this particular example does not involve a quasistellar object.

Another case, involving a quasistellar object, is Markarian 205 and NGC 4319. Daniel Weedman (Vanderbilt University),[6] using statistical arguments, said that the two objects were probably physically associated, although they had very different redshifts. Arp[7] then used a narrow pass-band filter in the region of the $H\alpha$ line of hydrogen to photograph the objects; he found a luminous filament joining them.

In 1970, Arp[8] had analyzed the distribution of quasistellar objects on the sky and shown that they statistically fell closer to the bright galaxies in the sky than the same number of randomly distributed objects would fall. Recently Burbidge, his wife Margaret (the new director of the Royal Greenwich Observatory), Philip Solomon and P. A. Strittmatter (La Jolla) have produced new evidence about associations between bright galaxies and quasistellars.[9] As Burbidge explained, depending on the number of objects in the region, the closer together two objects are, the more probable it is that there are real associations between them. When you try to correlate quasistellar objects with radio sources and galaxies, you get an interesting selection effect. If the quasistellar that is identified as a radio source is quite close to the galaxy, you will get a statistically significant result. But if it is too close to the galaxy, there is a strong probability that you would have identified the galaxy and not the quasistellar as the source itself. And if that is true, you won't know the quasistellar exists—you will be told that it is a radio galaxy, even