search & discovery

Quasars are relatively local. Except those that are not

How far away are the quasars? Either they are at cosmological distances, moving at a substantial fraction of the velocity of light—if you believe that their enormous red-shifts are of a piece with the general Hubble recession of the galaxies; or they are comparatively local—if you worry about their extraordinary luminosity and short-term variability. Each viewpoint has its own adherents; each adherent has a persuasive argument.

Two recent contributions to quasar astronomy only stir up the argument further. One quasar has been found that seemingly consists of two components moving apart at about ten times the velocity of light, if you accept the cosmological distance scale. And another has been found that looks as if it is embedded in a cluster of galaxies, sharing the same red-shift with at least one galaxy of the cluster, and so suggesting very strongly that it is at the same distance as the galaxy and is receding from us at the normal Hubble velocity for that distance.

Long-baseline observations. Last year a team of radioastronomers[1] from Massachusetts Institute of Technology, Goddard Space Flight Center, Jet Propulsion Laboratory and the University of Maryland brought a long-baseline radio interferometer to bear on quasars 3C 279 and 3C 273, with the aim of studying the occultation of 3C 279 by the sun on 8 October. The two telescopes making up the interferometric pair were MIT's Haystack antenna in Massachusetts and JPL's Goldstone "Mars" antenna in California; the baseline is about 3900 km long, which, at the operating wavelength of 3.8 cm, represents about 10^8 wavelengths.

What actually happened was that the interference-fringe signal from 3C 279 showed two "nulls," or zeroes in the fringe amplitude, each day for the 12 days of observations (except for a few days when the ray path passed so close to the sun that few fringes were visible). This effect can be explained as an interference between the signals from two point sources of equal strength at the position identified as 3C 279. The daily recurrence is due to the ro-

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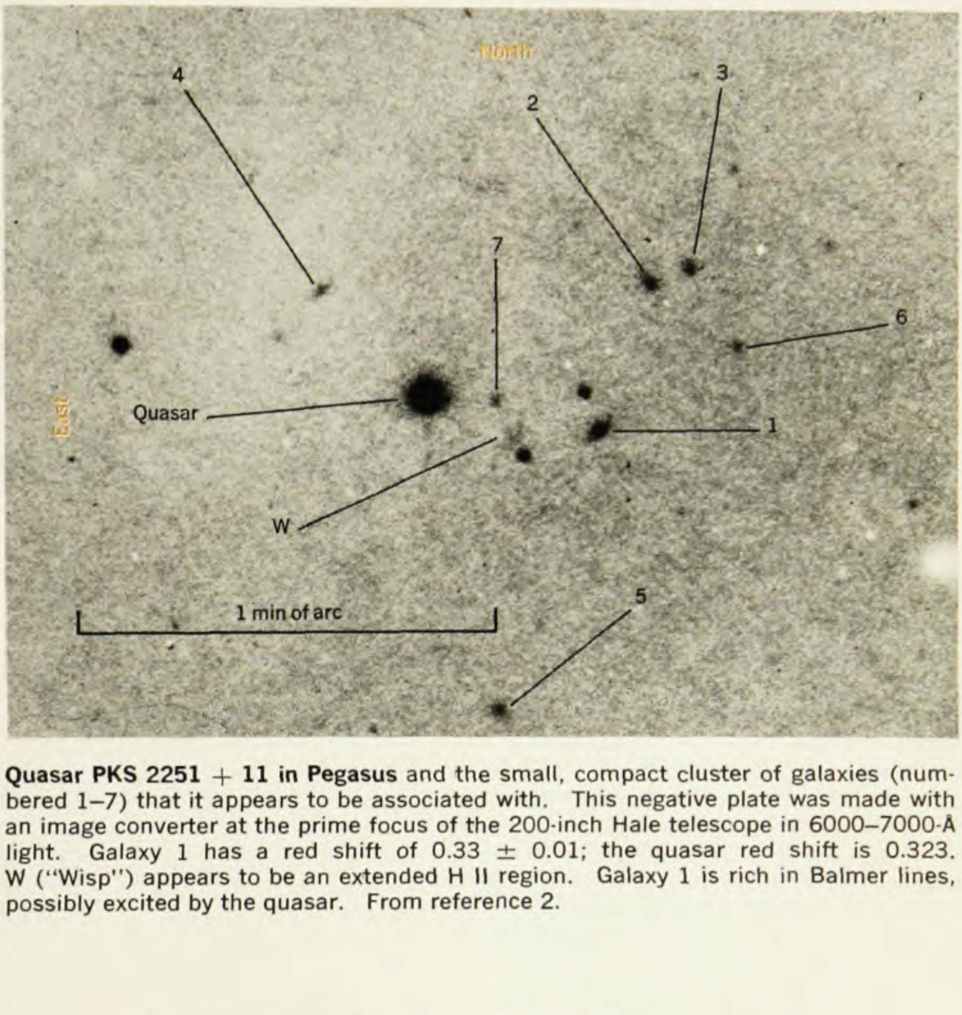


Quasar PKS 2251 + 11 in Pegasus and the small, compact cluster of galaxies (numbered 1–7) that it appears to be associated with. This negative plate was made with an image converter at the prime focus of the 200-inch Hale telescope in 6000–7000-Å light. Galaxy 1 has a red shift of 0.33 ± 0.01; the quasar red shift is 0.323. W ("Wisp") appears to be an extended H II region. Galaxy 1 is rich in Balmer lines, possibly excited by the quasar. From reference 2.

Long-lived kaon shows no 2-muon decay

The mysterious long-lived K meson has produced another surprise. An experiment to look for $K_L^0 \rightarrow \mu^+\mu^-$ has failed to find any such decays and has established an upper limit to the branching ratio (for two-muon decay compared to all decays) of 1.82×10^{-9}, with a 90% confidence level. Straightforward theoretical estimates had predicted a branching ratio of about 10^{-8}, but in any case a fairly plausible lower bound of 6×10^{-9}, more than three times larger than the experimental upper limit. The experiment was done at the Berkeley Bevatron by Alan Clark, Tom Elioff, Clive Field, Henry Frisch, Rolland Johnson, Leroy Kerth and William Wenzel, all of Lawrence Radiation Laboratory, Berkeley (*Phys. Rev. Lett.*, 28 June).

The Berkeley group originally did their experiment to see if you might have a much bigger branching ratio from some exotic mechanism producing the two-muon decay. The decay might have occurred through a direct coupling of hadrons to a neutral current. The known weak current is one that always produces a charged final state of leptons. A neutral current would produce a final state whose total leptonic charge adds up to zero.

Another exotic mechanism for producing two muons is through higher-order weak interactions. In that case the K_L^0 could virtually dissociate into two muons and two neutrinos; the neutrinos would then annihilate each other leaving the two muons. The probability of decay by such a mechanism is difficult to estimate but is expected to be very small.

On the basis of the electromagnetic and weak interactions alone, the observed two-photon decay of K_L^0 (with a branching ratio of 5×10^{-4}) is expected to produce the muon-pair decay through conventional quantum electrodynamics. L. M. Sehgal (Tata Institute, Bombay), and Chris Quigg and J. D. Jackson (Berkeley) and others calculated the imaginary part of the amplitude from unitarity considerations. This imaginary part gives one a lower bound on the two-muon decay rate. They assumed only a two-photon intermediate state and used the measured value of $K_L^0 \rightarrow \gamma\gamma$ to obtain a "unitarity" lower limit of 6×10^{-9}. Other intermediate states are possible, of course, such as a three-pion state or two pions and a gamma, but these are more difficult to calculate. Such contributions have been estimated by Brian Martin (University College London), Eduardo de Rafael (CERN) and Jack Smith (State University of New York at Stony Brook) to affect the branching ratio by at most 20%.

If the Berkeley experiment is right and the experiment that measures $K_L^0 \rightarrow \gamma\gamma$ is right, something theoretical has to give. What assumptions go into the calculation? One is that the two-photon intermediate state dominates the imaginary part of the amplitude. Another assumption is that muons do not interact strongly with each other, or for that matter, with anything else. If there is a muon-muon interaction, it might account for the small branching ratio. Two more assumptions could be wrong: quantum electrodynamics and unitarity (the idea that probability is conserved); however, this is highly improbable.

Another inherent assumption is that CP is conserved in the decay. If, however, we allow for a CP violation, then we can have both a CP violation in the decay amplitudes for $K_L^0 \rightarrow \gamma\gamma$ and $K_L^0 \rightarrow \mu^+\mu^-$, and a CP-violating parameter ϵ in the neutral kaon states. If one neglects terms proportional to ϵ, then the introduction of CP violation cannot explain the present experimental result but yields a bound on the amount of CP violation in the decay $K_L^0 \rightarrow \gamma\gamma$. Glennys Farrar and S. B. Treiman (Princeton) have calculated an upper limit on such a CP violation. Norman Christ and T. D. Lee (Columbia), by retaining the terms proportional to ϵ, can explain the experimental result only if the decay $K_S^0 \rightarrow \mu^+\mu^-$ has a branching ratio between 1×10^{-5} and 5×10^{-7}, which is much larger than the previous estimates. While this is consistent with the present experimental upper bound of 7.3×10^{-6}, the validity of the lower bound can be established or disproved by an order-of-magnitude improvement on the present experimental limit on the branching ratio of $K_S^0 \rightarrow \mu^+\mu^-$.

A previous experiment, an Aachen-CERN-Torino collaboration, had put the limit as less than or equal to 2.6×10^{-8}, a value higher than the unitarity bound. —GBL

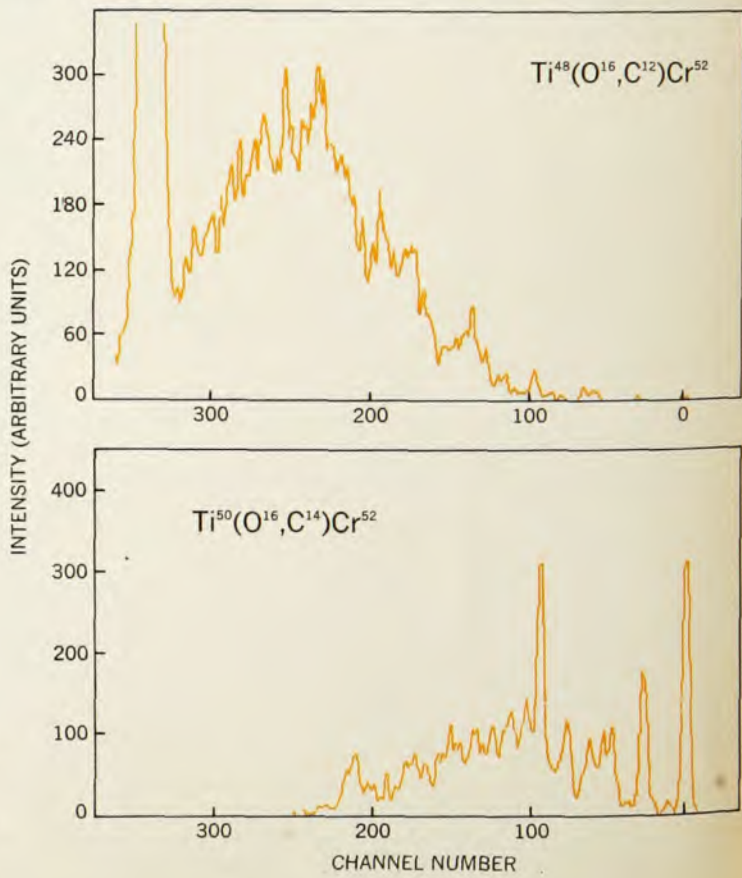
Saclay and Argonne see nuclear quartet states

If you bombard Fe^{56} with O^{16} ions, you can observe C^{12} ions being emitted, which means that an alpha particle (really two protons and two neutrons whose relative motions are probably correlated as they are in an alpha particle) has been incorporated in the residual nucleus—in this case Ni^{60}.[1] The spectrum shows certain selected states and not others. That is, at certain specific energies the alpha particles find an easy way to get in—the system appears to resonate. Such experiments with alpha-particle transfer reactions are exciting great interest among nuclear physicists.

Alpha-particle transfer reactions were first studied using (Li^6, d) and (Li^7, t) reactions at low energies on light nuclei in the 1p shell. When higher energy lithium ions became available, the work was extended to the sd shell, principally by a group at the University of Pennsylvania. Later, with still higher energy lithium ions, experimenters at Argonne tried to do alpha-particle transfer on heavier nuclei beyond the sd shell. They found that even for Ca^{40} the yield for such transfers had dropped off almost completely.

The Argonne experimenters then decided to look for the (O^{16}, C^{12}) reaction in Ca^{40} and found that with 48-MeV oxygen ions the peak yield to low lying states in Ti^{44} was one or two hundred microbarns per steradian, at least a factor of ten higher than the upper limit with Li^6 ions. The group, Arnold Friedman, Terry Fortune, George Morrison and Rolf Siemssen, reported their initial results two years ago.[2]

Meanwhile in France Vincent Gillet and A. Jaffrin at Saclay, and in the U.S. Michael Danos and A. Arima at the National Bureau of Standards were sug-



Spectra for alpha-particle transfer (top) and two-proton transfer compared. Alpha-transfer spectrum is very weak at energies up to a few MeV whereas two-proton transfer spectrum shows strongly excited states. At higher energies the latter shows no peaks whereas the alpha-transfer spectrum shows strong isolated states.