SHORTER CONTRIBUTIONS

P. A. Sturrock: Observational evidence indicates that the same explosion mechanism occurs in both quasars and radio galaxies, giving rise to jets or to single or double radio clouds. An understanding of the nature of quasars and of the structure of radio galaxies is tied inextricably to the understanding of this explosion mechanism.

An explosion is an instability. This instability converts stored energy efficiently into the kinetic energy of high-energy electrons – and probably also high-energy protons. The instability therefore develops strong electric fields. This indicates that the explosion is a plasma instability. Further considerations indicate that the stored energy is magnetic in form. In these respects the explosion is the same as a solar flare, and is therefore interpreted as a 'galactic flare'.

This interpretation of the explosion mechanism suggests the following model of quasars and radio galaxies. The condensation of an object of galactic mass in intergalactic space containing a weak (about 10^{-7} gauss) intergalactic magnetic field leads to the initial formation of a compact object, identified as a quasar or a galactic nucleus, which is coupled magnetically to intergalactic space. The magnetic-field configuration contains current sheets. The tearing-mode resistive instability may occur in the vicinity of these sheets, giving rise to a recoupling of the magnetic field lines, permitting the magnetic field to relax to a lower-energy state. Certain field configurations, which seem likely to arise, may give rise to the formation of a jet, or of a single or a double radio cloud.

In this framework, one is led to interpret a quasar as an evolving form of a galactic nucleus. The magnetic field plays an important role in the formation of a massive compact mass, both by enhancing the accretion process and by providing a mechanism for getting rid of angular momentum. It is believed that, at a certain stage, the mechanism for propagation of angular momentum becomes ineffective so that further accretion leads to the formation of the main body of the galaxy.

S. von Hoerner: It still seems possible to explain quasars by stellar collisions with subsequent explosions, as first mentioned by T. Gold (Texas Symposium 1964). I have made some estimates with the following results.

If we assume all stars to be like the Sun, then a stellar cluster in virial equilibrium (or the dense centre of a larger system) has only two degrees of freedom; its radius R and the number N of stars. If we want stellar collisions to continue for a longer time, then the colliding and exploding stars must be replenished by dynamical interaction,

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which means that the collision time t=(mean free path)/(r.m.s. velocity) must equal the relaxation time T. The condition $t=T$ then leaves only *one* degree of freedom, which we will use up by demanding a collision rate, $C=N/t$, of $C=10$ collisions/year to explain the time-scale of the variability.

Insertion of only one number, $C=10$ col/year, makes the system entirely defined and yields $R=0{\cdot}01$ parsec for its radius, $M=3\times10^6\ M_\odot$ for its mass, and $t=T=3\times10^5$ years for its lifetime; these are just the values required for quasars (at cosmological distance) from completely different arguments. If we further assume that the energy, released by explosions and transformed into radiation, is $\frac{1}{2}\%$ of mc^2, we derive a luminosity of $L=10^{46}$ erg s^{-1}, again just the right value. Using only *one* free parameter yields a good fit for *five* quantities (C, R, M, T, L), which seems to support the collision hypothesis (if it is not just chance, of course).

But it is impossible to obtain such an extremely high density ($10^{12}M_\odot$ parsec$^{-3}=10^{-10}$ g cm^{-3}) from a more normal one within 10^{10} years by stellar-dynamical means; an estimate gave a decrease in radius of only a factor of 10. The stellar system thus must have started with already a very high density (10^{-13}g cm^{-3}) provided in the gaseous state before the formation of stars. The question, whether or not a stellar system can finally produce collisions, then mainly depends on the maximum gas density which can be reached, in the centre of a cloud or of a rotating disk, before star formation sets in. For comparison: with a density of 10^{-13} g cm^{-3}, Jeans' criterion for formation of stars of solar mass gives a temperature of 400 °K. (I would like to add that the observed dense centres of spiral and elliptical galaxies, too, must have been provided in the gaseous state.)