out full three-dimensional hydrodynamic calculations to check our results more accurately. Hydrodynamic simulations of fuelling processes involving stellar collisions have also been performed recently, and the corresponding mass losses were calculated [5].

Disruption Frequency

Astrophysical interest in explosive stellar disruption by massive black holes (*via* tidal forces or *via* collisions) is constrained however by the statistical frequency of such events. Collisional type disintegration depends sensitively on the stellar distribution of stars around the black hole. It is clear that the presence of a massive central object in a stellar cluster modifies the stellar distribution, and this is likely to be one of the reasons why globular clusters (which probably harbour tight binaries instead of massive black holes) and stellar clusters in galactic nuclei have different stellar distributions.

The stellar distribution function depends, in general, on the position, star velocity and time. Assuming spherical symmetry, the dependance can be reduced to two parameters: the orbital energy and the angular momentum per unit mass of a star. Another simple assumption, that the stellar distribution is independent of time, allows some analytical work to be done. However, stars with bound and unbound orbits provide different contributions to the stellar number density.

Bound and unbound orbits

Stars on unbound orbits have a Maxwellian distribution of velocities outside the accretion radius (the radius of gravitational influence of the black hole) and their distribution is given to a good approximation by the celebrated isothermal sphere, characterized by a mass M_c and a core density n_c. For a typical galactic nucleus, $M_c \approx 10^6$ to 3×10^8 $M_\odot$ and $n_c \approx 3\times10^{-36}-3\times10^{-34}$ km^{-3} (the corresponding dispersion velocity being $\approx$ 150–1000 km/s).

Unbound stars have a number density $n(r) \sim r^{-1/2}$ inside the accretion radius so it is possible to calculate their rate of penetration into the tidal radius and the collision radius with a view to estimating the total mass of gas released by stellar disruptions. The tidal contribution turns out to be $\approx 1\ M_\odot/\text{yr} \times M_8^{4/3}$ and the collisional contribution $\approx 0.1\ M_\odot/\text{yr} \times M_8^3$ (where M_8 is the mass of the black hole in units of $10^8\ M_\odot$).

Bound orbits are confined within the accretion radius. The velocity distribution is no longer isotropic because the stars disappear as soon as they penetrate the tidal radius. The stellar number density reflects an accumulation of stars in the vicinity of the collision radius — a "cusp" in the stellar distribution that favours mostly collisional disruptions.

More general numerical simulations — taking into account the anisotropy of stellar velocities and time dependance — have been performed [6]. The growth of the central black hole is governed by the capture of the stellar debris: after a brief phase of maximum activity, the stellar cluster is exhausted and the black hole accretion rate as well as the accretion luminosity decrease with time as $t^{-1.5}$. The numerical results confirm the idea that moderately active galaxies can be powered by tidal disruption of stars around a $10^8\ M_\odot$ black hole, whereas the more powerful quasars require stellar collisions around a $10^9\ M_\odot$ black hole, or accretion of extragalactic matter.

The modelling of active galaxies is still in its infancy, and much theoretical work (guided by observations) is needed. Some important issues have not yet been taken into account, such as effects arising from encounters of stars within the accretion disk and the influence of multiple massive black holes. Indeed, some giant galaxies located at the cores of clusters of galaxies indeed show evidence for a multiplicity of active centres.

Conclusions

The study of the interactions between stars and a giant black hole is extremely interdisciplinary, involving general relativity, stellar structure, nucleosynthesis and galactic dynamics. The production of specific heavy isotopes in stellar pancakes, as well as dynamic features of ejected gases, should be detected shortly using advanced spectroscopic techniques. They may constitute definite signatures of the existence of large black holes in the cores of galaxies.

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Spanish Spending

To redress the woeful state of science and technology in Spain, the newly elected national government decided in 1982 to increase government spending on R. and D. from 0.35% of GNP in 1983 to a planned 1.3% by 1992 (which is still roughly half that for France and the Federal Republic of Germany). A three-year National Plan was launched in 1988 and its Secretary General recently reported that spending in 1989 had reached 0.9% of gross national product, divided among 19 principal themes and five special programmes.

The Plan comprises market oriented National Programmes of the Permanent Interministerial Commission of Science and Technology (CICYT), the Sectorial Programmes for basic research of the Ministry for Science and Education, two horizontal programmes (high energy physics and technology transfer), and special nationally-funded programmes that can be set up by any of the Spain's 17 autonomous communities. Catalonia, for example, with 25 per cent of Spain's GNP has a major programme in fine chemicals.

New Materials and Universities Gain

Of the Plan's 19 703 million pesetas spending in 1989 about 25% went to form researchers, resulting in a threefold increase in the number of university scholarships since 1983. The remainder covered joint projects with industry (21%) and infrastructure investments and project financing (54%) where the new materials theme was the winner (with 16.2%) ahead of information technologies and biotechnology (with 14.5 and 13.7% respectively). The largest autonomous programme (fine chemicals) represented 1.3% and high energy physics roughly 3.8%.

The universities have benefited most so far from the increase in research spending. They have been awarded 56% of the infrastructure investments as compared with 22% for the CSIC which is the national research organization grouping 2000 researchers in numerous centres. The intention is to strengthen the universities' research capacity and to direct it away from the traditional bias for fundamental research towards applied sciences that require greater spending on experimental facilities.

Links with EC Programmes

It was planned right from the start to couple the National Plan with European Community programmes. For instance, proposals for research projects (in both the sectorial and national programmes) can be submitted anytime if they form part of an EC proposal; otherwise there are deadlines. The policy has worked since from the time it joined the EC until the end of 1988, Spain had received 141 MECU for R. and D. from the Community (almost exactly the National Plan's 1989 budget).