50 & 100 YEARS AGO

50 YEARS AGO

Interference between plant viruses was first demonstrated in plants infected with tobacco mosaic virus. Although several theories have been proposed to explain interference ... there is little evidence on the mechanisms involved. In the experiments described below interference was measured by the ability of an inoculum that does not produce local lesions (interfering strain) to affect the local lesions produced by another strain when the two are inoculated simultaneously to susceptible leaves ... The present results suggest that sap from virus-infected plants contain, in addition to infective particles, another factor that inhibits infection ... Centrifugation ... showed that infectivity and interfering activity occurred in the same zone in the gradient. If interference systems occur, then these appear to be in some way associated with virus particles.

A. D. Thomson

From *Nature* 27 August 1960.

100 YEARS AGO

On August 20 occurred the bicentenary of the birth of Thomas Simpson, who may be regarded as one of the last of the English school of mathematicians of the eighteenth century. Newton, Halley, the Gregories, Muston, Demoivre, Brook Taylor, Maclaurin, had all passed away before Simpson reached middle age ... With the sole assistance of Edmund Stone's translation of l'Hôpital's "Analyse des Infiniments Petits," Simpson wrote "A New Treatise on Fluxions," which was considered a notable contribution to the literature of that comparatively new subject. In 1743 ... Simpson obtained a post as professor of mathematics at the Royal Military Academy, Woolwich ... After holding his post at Woolwich for eight years, he was seized with illness, caused, it was thought, by overwork ... He journeyed to Bosworth in February, 1761, and died there on May 14.

From *Nature* 25 August 1910.

On page 1082 of this issue, Mayer *et al.*[1] investigate, by means of high-resolution numerical simulations, the conditions that can drive the formation of an SMBH 'seed' during the merger of massive galaxies in the young Universe. The authors study a process that can leave behind a black hole that is very massive at birth. Once this newly born SMBH seed starts to grow, by accreting matter from the dense cloud of gas in which it is embedded, we can hope to spot it as a quasar — a compact and extremely bright object as small as a star but as luminous as an entire galaxy. SMBHs have been recognized as the 'engines' that power quasars, and the energy emitted by material plunging onto an SMBH as the source of such power. About 10% of every parcel of matter is converted into energy during the infall.

However, SMBHs are not always active as quasars. Quasars were very common in the early Universe — up until the Universe was about 40% of its current age of 14 billion years. But they slowly disappeared, leaving behind quiescent SMBHs. The masses of quiescent SMBHs in nearby galaxies correlate with the properties of their host galaxies[2], suggesting that a single mechanism underpins the assembly of both SMBHs and galaxies. However, most of the galaxy-formation models involving quasar and SMBH evolution neglect research into the physical processes that formed SMBHs, and take simplistic approaches. This is a crucial missing ingredient: knowledge about the first SMBH seeds is necessary when investigating how SMBHs grow with their host galaxies over cosmic time.

Mayer *et al.*[1] attack this problem by focusing on the environment in which an SMBH seed might form. They find that the collision and merging of two massive young galaxies produces a massive gas disk, which is born in an unstable configuration, with a spiral pattern that transports mass towards the disk's centre. Within only 100,000 years, more than 100 million solar masses of gas are accumulated in the disk's central region, forming a dense cloud of gas. The core of this cloud eventually collapses into a supermassive star (with masses of tens of thousands of solar masses or more), the core of which ultimately collapses into an SMBH seed. The timescale for the formation of the cloud is much shorter than the 10^8 years that are needed to convert the disk's gas into stars. Gas is therefore available for SMBH formation rather than being consumed to form stars. Gas collapse driven by galaxy mergers thus overcomes the major difficulty of previous collapse models in isolated galaxies, in which star formation had to be artificially suppressed to prevent it from consuming the gas reservoir.

The highly dynamic, out-of-equilibrium conditions of galaxy mergers, and the details of gas infall, can be studied only with numerical tools such as those used by Mayer and colleagues[1]. The authors' results tie in nicely with Begelman and colleagues' proposal[3,4] that a supermassive star forms when gas-infall rates exceed the large threshold value of about 1 solar mass per year. According to this model[3,4], although the star's core collapses into a black hole, material piles up on the star's surface and allows the hole to be efficiently fed; this black-hole-powered star is known as a quasistar[3].

Mayer *et al.* find that such a large gas-infall rate can indeed be produced through galaxy mergers. What's more, the combination of their gas-infall process[1] with the quasistar model proposed by Begelman *et al.* can explain the existence of powerful quasars at a time when the Universe was one-tenth of its current age[5]. These luminous quasars can be powered only by SMBHs of billions of solar masses. (There are galaxies that weigh, in their entirety, less than these SMBHs.) Explaining the existence of such SMBHs less than one billion years after the Big Bang is challenging, and requires either a very steady growth of the SMBHs or that the seeds are quite massive. Mayer and colleagues' results are appealing in this context because the SMBH seeds that form during galaxy mergers are indeed very massive at birth.

However, the black-hole formation mechanism proposed by Mayer *et al.* seems to be efficient only for galaxies that were already very massive at early cosmic times; these galaxies are expected to evolve into objects the size of the Milky Way or larger. Although this finding is broadly consistent with observations, which indicate that most SMBHs are hosted by large galaxies, SMBHs have also been found in dwarf galaxies[6] (more than a 100 times smaller than the Milky Way). Of course, it is possible that smaller SMBHs in low-mass galaxies may have formed through other mechanisms[7], for instance as remnants of the first generation of stars. These stars are predicted to have had masses up to several hundred times that of the Sun, and so probably left behind 'almost-massive' black holes at the end of their life.

The James Webb Space Telescope (the successor to the Hubble Space Telescope), future X-ray missions such as IXO and the gravitational-wave telescope LISA will all have the technical capabilities to detect quasars and SMBHs in the early Universe. These therefore promise to provide further insight into the process that generates SMBHs 'from scratch'. ■

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