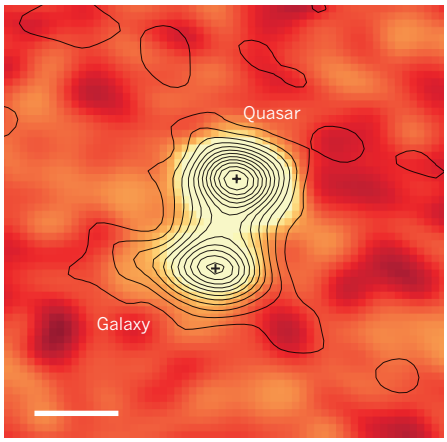

Figure 1 | A distant quasar and its companion galaxy. Quasars are extremely bright astronomical objects, thought to be powered by black holes that are at least a billion times more massive than the Sun. Decarli *et al.*[5] have discovered four massive star-forming galaxies in the neighbourhoods of quasars in the early Universe. Shown here is an image of one of the galaxies in the vicinity of the quasar PJ231–20 (the centres of the two objects are denoted by crosses). The authors looked for a particular spectral-line emission associated with singly ionized carbon that is particularly prominent in spectra of massive star-forming galaxies in the early Universe. The colour scale indicates the strength of this emission from low (dark red) to high (yellow). The black contours are isophotes, which join points of equal light intensity. Scale bar, 10 kiloparsecs.

There have been many attempts to test this general model for early-quasar growth by looking for galaxies around luminous quasars in the early Universe. However, such efforts have been either limited by the poor spatial (line-of-sight) resolution of standard search methods for distant galaxies[7–11], or restricted by techniques that are sensitive to only low-mass galaxies around quasars[12,13]. These studies have provided support for the idea that luminous quasars formed in high-density environments of the Universe, but the evidence has not been overwhelming[14].

The Atacama Large Millimeter/submillimeter Array (ALMA) observatory in Chile has provided astronomers with a powerful tool with which to search for spectral-line emission from massive star-forming galaxies in the immediate vicinity of bright quasars. ALMA can achieve this feat because of its immense radiation-collecting area and design as an interferometer — an array of antennas that are linked to combine astronomical observations. The latter allows ALMA to obtain an emission spectrum at every position in space over its 25-arcsecond field of view (about 1.5% of the full Moon's angular diameter).

Decarli *et al.* used the unique capabilities of ALMA to observe 25 luminous quasars that existed less than 900 million years after the Big Bang — at redshifts larger than 6 (the higher the redshift of a cosmological object, the younger the Universe was when the object emitted its light). They then carried out a blind search for additional sources in the same volume of space as a quasar, with a separation of less than 70 kiloparsecs in the plane of the sky and 2 megaparsecs along Earth's line of sight.

The authors targeted an emission line associated with singly ionized carbon that is particularly prominent in spectra of the interstellar medium of galaxies in the present-day Universe and of massive star-forming galaxies in the early Universe[15,16]. In addition to finding strong emission from the studied quasars, Decarli *et al.* discovered four bright line-emitting sources in the same observations (Fig. 1). The authors justifiably interpreted these sources as massive star-forming galaxies.

Decarli and colleagues' identification of bright galaxies in the vicinity of distant quasars is important for at least two reasons. First, it provides definitive and convincing evidence that luminous high-redshift quasars formed in particularly dense environments, and gives us a concrete and salient answer to how rich these environments are in massive galaxies. By probing luminous quasars at redshifts greater than 6, Decarli *et al.* have substantially extended the results from previous studies that presented related findings at redshifts of 4.8 (ref. 17) and 5.3 (ref. 18).

Second, on the basis of a blind search around bright quasars, the authors have detected what are likely to be three of the most massive star-forming galaxies discovered so far at redshifts larger than 6. Remarkably, their efforts seem to have outstripped dedicated searches for such galaxies that have much larger fields of view (several times the full Moon's angular diameter)[16,19]. The authors' galaxies have high luminosities and lack contaminating light from their neighbouring quasars, potentially allowing a detailed characterization of galaxies in the early Universe to be made.

The discovered sources seem certain to be targets for ALMA, the James Webb Space Telescope and other facilities in the immediate future. Such follow-up observations are needed to make sense of the full scope of Decarli and colleagues' findings, because our understanding of the sources' properties is limited by the current data. Nevertheless, the authors have presented an extremely valuable pathfinding study that could bring about a fundamental change not only in our probing of the regions surrounding bright high-redshift quasars, but also in how astronomers look for the most massive galaxies in the early Universe. ■

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50 Years Ago

The turnover of endogenous protein is known to be of great importance in the differentiation of micro-organisms. For one thing, it can provide raw material for the synthesis of enzymes and other proteins that will allow growth to continue in a changed environment … Recent results obtained by N. S. Willets… have added significantly to understanding of the mechanism of protein turnover … The elucidation … offers intriguing possibilities for future experimentation, and will be vital to a fuller understanding of processes of differentiation in living cells.
From *Nature* 27 May 1967

100 Years Ago

What is Instinct? Some Thoughts on Telepathy and Subconsciousness in Animals. By C. Bingley Newland — Mr Newland, as sportsman and field naturalist … has ventured on a line of interpretation where verification is impossible. His study of adaptive behaviour has led him to the conclusion that "the marvellous precision and fitness of these actions can only be attributed to Omniscience manifesting in the creature." … he tells us that "the creatures involved make no tentative experiments, but the perception of how and when to act comes to them subconsciously." But it is not exactly their own subconscious mind that operates; it is a "subconscious principle directly transmitted from the 'mainspring' — All-Mind." The life-principle (soul) of the insect or other members of the animal world is a centre of subconsciousness, temporarily set apart, but ever "in touch" with the All-Conscious. Hence their infallibility!
Mr Newland is altogether too metaphysical.
From *Nature* 24 May 1917