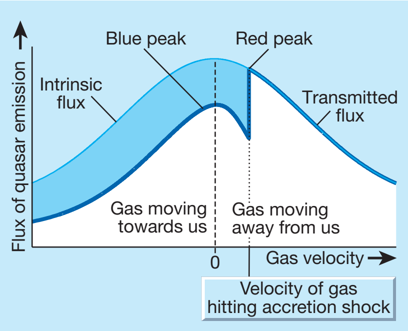

Figure 1 **Quasars, black holes and dark matter. Barkana and Loeb[1] show that the observed flux of light from a quasar is modified as gas falling in towards the black hole at its centre, under the gravitational influence of a surrounding halo of dark matter, absorbs some of the radiation. If the same amount of gas is falling in from all directions, the flux as a function of the gas velocity relative to the observer takes on a distinctive 'double-horn' profile. The 'red' peak arises because gas moving away from the observer towards the centre of the quasar hits the accretion shock — a shock barrier due to gas ionization — and inside this barrier the transmitted flux follows the intrinsic spectrum, as the gas no longer absorbs the quasar light. Although Barkana and Loeb have little information to work with so far, their model is in good agreement with the existing spectra of two high-redshift quasars.**

formation proceeds from the smaller to the larger galaxies through merging and interactions. Models that successfully reproduce the observed quasar luminosities at high redshifts[15–17] predict a relation between black-hole and dark-halo mass in remarkable agreement with what is observed in the local Universe.

The observations that triggered Barkana and Loeb's work[1] were spectroscopic studies by the SDSS collaboration of quasars at redshifts of 4.79 and 6.28. The quasar emission lines resulting from excited hydrogen atoms have characteristic 'double-horn' profiles, with distinct red and blue peaks (Fig. 1). Although gas along the line of sight to the quasar could absorb some of the emitted radiation and produce an asymmetric profile, previous attempts at modelling the SDSS quasar spectra in this way have been unsuccessful: absorbing gas that is moving away from the quasar, following the expansion of the Universe, can 'eat away' only the blue side of the emission line profile. Barkana and Loeb realized that if gas were falling in towards the quasar at the centre of the dark-matter halo, the characteristic double-horn profile would be produced.

As gas falls towards the quasar, an increasing volume becomes ionized. Barkana and Loeb's model predicts a sudden change in the fraction of neutral gas around 100 kiloparsecs (roughly 10^{18} km) from the quasar. At this radius an accretion shock sets in, producing a sharp cut-off in the absorption profile (Fig. 1) — as is seen in the spectra of the SDSS quasars (Fig. 2 on page 342). The velocity of the infalling gas, the radius of the accretion shock and the rate at which mass is being collected towards the centre all depend on the gravitational force exerted by, and hence on the mass of, the dark-matter halo.

Barkana and Loeb's calculations for the two SDSS quasars imply black holes of 10^8–10^9 solar masses. Relating these values to the dark haloes, as in hierarchical models, they find that these quasars are embedded in dark-matter haloes each of around 10^{12} solar masses. And, reassuringly, the mass collection rate is large enough that the quasar host galaxies could have been assembled on timescales shorter than the age of the Universe at a redshift of 6.28. But, as Barkana and Loeb admit, more observational data are needed for a rigorous test of their model.

What challenges lie ahead in the study of supermassive black holes? At present, hierarchical models cannot easily account for nuclear black holes with masses smaller than 10^5–10^6 solar masses[16,17]. If such black holes exist, they must be formed through a completely different mechanism — or the entire picture needs to be revised. In fact, the smallest supermassive black hole detected so far is at the centre of the Milky Way (with a mass of 3 million solar masses). Unfortunately, the dynamical signature of lower-mass black holes is subtle at best. Their detection in even the nearest galaxies poses a strong technological challenge as their 'sphere of influence' (the region of space within which the black hole dominates the gravitational potential of the surrounding stars) is smaller than the resolution limits of current instruments. Once again, the ball is in the court of the observers. ■

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100 YEARS AGO

Mr. H. A. Bryden contributes to the *Fortnightly Review* for January an article on the decline and fall of the South African elephant. It appears that the wild elephant has now practically ceased to exist south of the Cunene and Zambesi rivers. About the year 1830, elephant hunting in Cape Colony was prohibited by the British Government. Since that time, remaining herds have been carefully protected, and they still roam the dense jungles of the Knysna Forest and the Addo Bush in large numbers. It is a curious illustration of what a little timely preservation will do for wild creatures that often within a few miles of Port Elizabeth and Mitenhage there are strong troops of these animals, while one may travel elsewhere fifteen hundred miles up country and not succeed in finding a single wild elephant.

From *Nature* 22 January 1903.

50 YEARS AGO

The Nutritional Panel of the Food Group of the Society of Chemical Industry has arranged a series of meetings devoted to the subject "Food and the Future"…

Mr. F. Le Gros Clark spoke on the "Yardstick of Population" and posed the question, "Will there soon be too many of us?", pointing to an eventual finite limit to the population that could be supported by the world. Famines have always been local and temporary, never of world dimensions, but the real cause for alarm is that no one can foresee in what precise corner of the world hunger may occur…

Mr. Le Gros Clark traced the growth in population over the centuries, suggesting an eventual total of 8,000–12,000 million before stability is reached. The problem of their food supply requires not mainly a technological transformation but a revolution in the habits of men and methods of farming — an agrarian revolution on a world-wide scale. The initiation of this revolution, he said, should have started fifty years ago, before the pressure of population had become so great. Nowadays, we cannot be excused because of ignorance, as perhaps could our grandfathers, who had less factual knowledge. Most nations to-day, protested Mr. Le Gros Clark, are not giving the agricultural scientist and food chemist half the chance they should have of meeting the challenge.

From *Nature* 24 January 1953.