in units of the proton charge, each quark carries three kinds of a quantum number called colour. Colour is necessary to satisfy the antisymmetrical Fermi–Dirac statistics property of quarks in describing baryons as three-quark composites, the three quarks being in a colour-antisymmetrical state. Colour is also carried in eight different kinds by massless boson quanta (of spin one) called gluons. These are responsible for keeping the quarks 'glued' together in a hadron and are themselves also confined. One special property of colour forces mediated by gluons is the self-coupling of three gluons carrying different colours. As a result, the colour forces become weaker and weaker at shorter and shorter distances. This phenomenon is poetically described as 'asymptotic freedom' and seems to have been observed experimentally (see *News and Views* **277**, 349; 1979). These forces are believed to become stronger at greater distances. The literary acronym for this behaviour is 'infrared slavery' and this is what is supposed to be responsible for colour confinement. According to this view all coloured objects (such as quarks and gluons) should be confined and only colourless hadrons should be observable.

Given the self-coupling of gluons, one can expect to see as real, unstable particles of zero or integral spin, colourless composites made out of gluons alone. These are the hypothetical (at present) glueballs. A glueball may be visualised as a composite of two or three gluons, in analogy to the quark–antiquark picture of a meson or the three-quark picture of a baryon. Several glueballs are likely to exist at different masses. It has been argued (*Nucl. Phys.* **B 130**, 328; 1977) that, owing to the asymptotic freedom of the colour forces, the decay of the lowest mass glueball into the usual hadrons ought to be somewhat inhibited. Consequently, it is expected to be more stable than a typical meson of the same mass. It should have a lifetime of the order of 10^{-21} rather than of the order of 10^{-23} as is usual for mesons. Higher mass glueballs will of course be generally more unstable.

The existence of glueballs was first proposed by Fritzsch and Gell-Mann in 1972. However, they remained an idle curiosity until an intriguing suggestion by Freund and Nambu (*Phys. Rev. Lett.* **34**, 1645; 1975) linked them to an important feature of high energy hadron–hadron collisions. The total cross-section for such collisions depends very weakly on the energy – a behaviour which had for many years defied any real understanding in terms of the otherwise successful Regge picture of exchanges of Regge trajectories on which hadrons lie. Freund and Nambu could provide a credible explanation if the dominant exchanges are those of new Regge trajectories on which real glueballs lie. They required glueballs to exist with spins two, one and zero with masses around 1.5 GeV.

The very existence of glueballs – let alone their masses – is still a matter of considerable theoretical controversy. It was proved by Coleman (*Comm. Math. Phys.* **55**, 113; 1977) that, if the colour forces are described by the laws of classical physics, glueballs cannot exist. In a classical world a glueball would show up as a concentrated colourless gluon-made packet of finite energy which does not spread. Coleman has shown however that all classical packet-like solutions of this theory radiate away their energy very fast. Of course, the nonexistence of classical glueballs says nothing about the existence of quantum glueballs. However, it suggests that a glueball would be a purely quantum occurrence. The question of the existence of a glueball in a quantum field theory is a difficult one but has nonetheless received some attention. Arguments have been given (though not universally accepted) for the existence of such objects in a quantum theory of colour forces in lower dimensions, but none has yet been found for the $(3+1)$ dimensional space-time in which we live.

Instead of pursuing such a general approach, model-builders have considered the glueball question in specific dynamical models. The bag model, which has been developed particularly by the MIT group, is one such scheme. In this, each hadron is considered as a bag in which quarks and gluons are kept confined by chosen boundary conditions. The bag generates volume pressure and/or surface tension to produce confinement. Gluon wavefunctions have been treated by analogy to the transverse electric and magnetic modes of electromagnetic fields confined within a spherical cavity. This approach leads to the prediction of glueballs with spins zero and two and with masses slightly less than 1 GeV.

Another set of models has been pursued by lattice theorists, led by Wilson. They quantise space-time and consider the theory of colour forces on a four-dimensional Euclidean (that is, $x_1x_2x_3x_4 = it$) lattice with nearly vanishing lattice spacings. Quarks and antiquarks, instead of being continuous fields, are attached to lattice sites and gluons identified with the links between such sites. A quarkless glueball then is a closed box of links with no loose ends. Such objects have been shown to exist with spins zero, one and two and their masses calculated by Padé approximant methods to be around 1.5 GeV.

Glueballs have been looked for experimentally although they are generally very difficult to produce in hadronic collisions. The gluons by and large play a passive role in these reactions. However, they do play a pivotal part in the decay of heavy quark–antiquark bound states ('quarkonia') produced by electron-positron annihilation at high energies: for

Probir Roy is at the Tata Institute of Fundamental Research, Bombay, India.

Incest re-assessed

IN his advisory article on incest (*News and Views* **279**, 192; 1979), May reinforces his theoretical calculations on the deleterious effects of parent–offspring and brother–sister matings by reference to a Czechoslovakian study reported by E.O. Wilson. As presented, the study provides overwhelming evidence to support May's hypothesis; however a closer examination of the original data must raise a number of doubts as to the validity of the control group employed.

In her study (*Hum. Hered.* **21**, 108; 1971) Seemanova reported that the mean and the modal maternal ages of the non-incestuous control group at childbirth were 24.9 and 21 years while those of the father–daughter matings were 18.9 and 16 years and the brother–sister matings were 19.9 and 14 years. Since the Czech data referred to births from 1933 to 1970, the low modal ages of the mothers in the two incestuous groupings are particularly significant when viewed against the secular decline in the age of menarche during that period (Tanner *Growth at Adolescence* Blackwell, Oxford, 1962) and the high incidence of chromosomal anomalies and congenital malformations associated with pregnancies close to menarche (Carr *Adv. Hum. Genet.* **2**,201; 1971).

A second area of doubt concerns the imbalance between the biological fitness of the parents in the incestuous and the non-incestuous matings. Of the 141 incestuous mothers, 20 were mentally retarded (of whom two additionally were deaf-mutes, two had congenital syphilis and two were epileptics), a further two were deaf-mutes and three were schizophrenic. Among the 46 control mothers, a subgroup of the incestuous mothers, only two were mentally subnormal (one additionally being a deaf-mute) and two others were deaf-mutes. Similarly, of the 138 fathers in the incestuous matings 8 were mentally subnormal, 13 were chronic alcoholics, two had syphilis and four had committed suicide. In the non-incestuous grouping of 52 fathers, none were mentally subnormal, there were two chronic alcoholics and one case of polydactyly.

When considered in conjunction with the specific adverse social factors accompanying incestuous pregnancies, the conclusions on incest drawn on the basis of this particular study appear rather less convincing.

Chelsea College, London. A.H. BITTLES

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