the solid.

G. Cargill (Watson Research Centre, IBM) and Rosencwaig showed that the beam in a SEM may also be used to generate a thermal wave in a sample. A piezoelectric detector bonded to the back surface of the sample collects the acoustic wave generated by the thermal expansion in the solid. In this technique of electro-acoustic microscopy much smaller spot sizes can be used to illuminate the sample and the resolution is then only limited by the thermal wavelength. Submicron resolution should be possible using 1-10 MHz modulation frequencies. Rosencwaig demonstrated the detection of a 2 micron crack beneath a solder pad in a ceramic substrate. By selection of the appropriate phase of the electroacoustic signal subsurface imaging is possible. He presented images showing phosphorous dopant regions in a Si substrate beneath a SiO_2 layer.

A technique related to PAM again uses a modulated light beam to illuminate the sample surface. An infrared detector is, however, used to directly, but remotely, monitor the sample surface temperature. The detector output is a function of both the optical and thermal properties of the sample. P. Nordal (Laser and Applied Optics Laboratories, Blindern) showed that this technique of photoinfrared microscopy was sufficiently sensitive to detect a single monolayer of aspartic acid in a chromatogram.

In conclusion, scanning microscopes offer higher resolution and a natural imaging environment for living cell cultures, whilst in the field of non-destructive evaluation, give information inaccessible to conventional techniques. □

Gluon fusion

from V. Barger

THE production of particles made of charm or b-flavor quarks has been under intensive study for several years. Of special theoretical interest in the production of these quark flavors is the large mass scales involved, which permit perturbative calculations of strong forces using the theory of quantum chromodynamics (QCD). Recent data from experiments with muon beams at CERN[1] and Fermilab[2] give evidence for copious production of charm and anticharm, which can be compared with QCD expectations. The successful description of these data was a major topic[3] at the XXth International Conference on High Energy Physics held at the University of Wisconsin-Madison in July.

A muon beam (μ^+ or μ^-) interacts with a nucleon target via the electromagnetic interaction through the exchange of a virtual photon. In the scattering of the virtual photon with a gluon constituent (g) of the nucleon, a charm-anticharm quark pair ($c\bar{c}$) can be created (Fig. 1). These quarks materialize with probability unity as charmed hadrons through the confinement force. The subsequent weak decays of the charmed particles can lead to additional muons (Fig. 2), which provide a clear experimental signature for charm events. On the average, the decays of a charm particle yield a muon about 10 per cent of the time, with a μ^+ originating from charm decay and a μ^- from anticharm decay. Counting the primary muon from the beam scattering, charm pair production results in dimuon and trimuon events. The muon emitted in charm decays is accompanied by a neutrino (ν), whose energy and momentum are unobserved. Thus multimuon events from $c\bar{c}$ production are characterized by missing energy.

Unlike the muon signals from charm decays, multimuon sources from other electromagnetic processes mediated by two virtual photons have zero or little missing energy. Fortunately, contributions from these non-charm sources can be reliably estimated.[4] By appropriate experimental cuts the charm signal can be isolated.

The theoretical calculation of photon-gluon fusion[5] (Fig. 1) depends on the strength of the gluon to $c\bar{c}$ strong interaction coupling, which is fixed by QCD analyses of other reactions. Another necessary ingredient is the probability density for finding a gluon carrying some fraction of the nucleon momentum. From inelastic electron scattering, it is known that gluons carry about half of the nucleon's total momentum. Using conventional theoretical prejudices about the shape of the gluon probability distribution,[6] the predictions of the photon-gluon fusion model are found to be in excellent agreement with the multimuon data.

The fusion approach also applied to the production of bound $c\bar{c}$ states, such as the ψ-particle. It is assumed[7] that ψ-production is proportional to the density of $c\bar{c}$ states produced near the ψ-mass. The model is in good agreement[8,9] with "elastic" ψ-production events[1,2] that have little accompanying hadronic energy. For inelastic ψ-production additional fusion diagrams enter, with an extra quark or gluon carrying away energy.[10].

In hadron-hadron collisions the creation of $c\bar{c}$ or $b\bar{b}$ pairs occurs via gluon-gluon fusion and via the fusion of light quarks q with their antiquarks $\bar{q}$ (Fig. 3). Data on the hadroproduction of the ψ and Υ particles allow the extraction of gluon distributions for pions, kaons, and nucleons. A consistent fusion description of the hadroproduction of heavy quark bound states emerges,[9] with the same gluon distribution for the nucleon as determined from virtual photoproduction.

These successes of the fusion model are somewhat clouded by the present situation concerning the hadroproduction of unbound charm, where the predicted rates are too small. One possibility is that yet to be calculated higher order QCD diagrams are important in hadron-hadron collisions. □

V. Barger is Professor of Physics at the University of Wisconsin-Madison.

Fig. 1

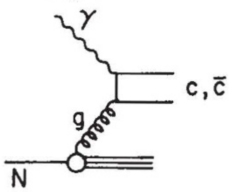


Fig. 2

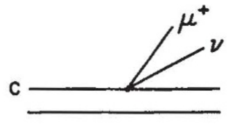
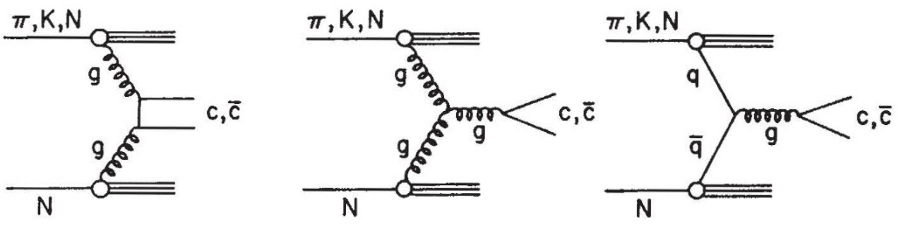


Fig. 3



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