dent of the sign of M and there are at most $(2J+1)$ subsystems of different M if J is the smallest of the values involved. Detailed line shapes for the patterns expected in the experimentally favourable cases of ammonia and hydrogen fluoride are also calculated by Skribanowitz and his colleagues, so that all that remains to be seen is whether such effects will be detected and how useful they will be for molecules of more complex and less well known spectra.

ELEMENTARY PARTICLES

Protons and Partons

from a Correspondent

THE Royal Society had a lot to contend with when it held its meeting on proton scattering at very high energies on March 8. For one thing the windows were vigorously shaken during the afternoon session by the car bomb in Whitehall, about a quarter of a mile away. It was, nevertheless, an absorbing meeting.

Three new devices have greatly extended knowledge of high energy collisions. The Russian 70 GeV/c accelerator at Serpukhov has provided precise data on elastic scattering and extensive bubble chamber data on particle production processes. The 300 to 400 GeV/c machine at the National Accelerator Laboratory (NAL) near Chicago has been running for about a year, and the first-generation experiments at the CERN intersecting storage rings (ISR) near Geneva are nearing completion. These machines take one from a laboratory beam energy of about 30 GeV, at the CERN proton synchrotron and the Brookhaven alternating gradient synchrotron, to the equivalent of about 2,000 GeV at the ISR. As Professor G. Cocconi (CERN) put it in his introductory talk, matter can now be studied at densities more than 100 times greater than the density in the nucleus, although the opportunity does not last for more than about 10^{-24} s. Only in the initial "big-bang" at the formation of a universe, or possibly in the "black hole" at the death of a large star, is such a density thought to be reached for a longer time.

Many of the data which were reported from the new machines cannot yet be explained theoretically, but there has been considerable progress since the international conference at NAL last summer. A potentially exciting suggestion comes from the ratio of positive to negative particles produced with large transverse momenta at the ISR. There is a clear excess of positive particles. The simplest explanation of this is that in the most "head-on" of proton-proton collisions, the constituent particles (or partons) which form the two protons make violent direct collisions with one another and go off at large angles. In the commoner "peripheral" collisions the individual partons are thought to act collectively. If there are only a few partons (three, for example) in each proton, then the fact that the proton has a positive charge requires a significant excess of positive over negative partons. The parton masses are apparently very large, for they have never been observed directly, but if the underlying process is a collision of mostly positive partons, the ordinary secondary particles observed at large angles will also be more positive than negative. If the number of partons in a proton were large, say thirty, then the fact that a proton has a single unit of positive charge would only have a small effect on the relative number of positive and negative partons, and hence could not be expected to bias the observed charge at large transverse momenta. There is no satisfactory model on which to base exact calculations of the effect, but this proton-proton scattering result fits in well with data on neutrino and antineutrino scattering obtained in the Gargamelle bubble chamber at CERN. Both experiments suggest that there is a small number of partons in a proton, and it is therefore possible that the partons may be "quarks" of relatively simple type suggested by Gell-Mann and Zweig in the early 1960s.

Another result from the ISR has allayed fears that the new machines would only probe deeper into "asymptopia", the energy region in which all measurable parameters would settle down to approach to a limiting behaviour. At Serpukhov energies, all total cross-sections seemed to be tending to a constant, but experiments at the ISR have revealed that the proton-proton cross-section goes up again by 10 per cent (see *Nature*, **242**, 233; 1973). Nobody knows why, although it may be associated with the increased range of masses available for diffraction dissociation as the energy increases. Other surprising results are the behaviour of the real part of the forward scattering amplitude, which seems to be passing through zero at the lower ISR energies but which may become positive at the highest energy, and the large numbers of particles produced with large transverse momenta. Some features of the data do agree well with previous predictions, the "scaling" behaviour of single particle distributions with energy for instance, but all the indications seem to be that a new region of physics is being opened up rather than that a predictable continuation of the old region is occurring.

Wolf-Rayet Systems and X-ray Binaries

MASSIVE X-ray binaries and Wolf-Rayet (WR) systems may represent different stages in the evolution of the same kind of object. In next Monday's *Nature Physical Science* (April 2) van den Heuvel lists the basic parameters of the five X-ray sources known to be associated with binary systems and compares these with parameters of nine double-lined and eclipsing WR binaries with known orbits. He argues that the large mass and intense radiation from the secondaries in the X-ray systems suggest that these are black holes or neutron stars, produced by the evolution of normal massive close binaries.

In such a system, mass is transferred from the primary to the secondary as it evolves, so that the primary becomes an almost pure helium star. The secondary grows to become a hydrogen-rich OB star, and the helium star ends its life as a type II supernova some 1.7×10^6 yr or less after the first stage of mass exchange; the residue, now the secondary of the evolved system, is a black hole or neutron star. Further evolution of the new primary leads to mass transfer on to this object and the production of X-rays 4 to 6 $\times$ 10^6 yr after the supernova event.

This is a commonly painted picture. But van den Heuvel now points out that during part of this evolutionary pattern the system is very like a WR binary. He has calculated the final binary periods resulting from spherically symmetric explosions of typical WR stars, assuming a remnant mass of either $M_\odot$ or 4 $M_\odot$. The test masses were chosen because the mass of the secondary in Cen X-3 is less than 0.84 $M_\odot$ and the mass of the secondary in Cyg X-1 is at least 4 $M_\odot$. For two known WR binaries, V 444 Cygni and CQ Cephei, these calculations indicate final periods close to those of the X-ray binaries. Four other WR systems could, it seems, evolve into X-ray binaries with periods only slightly greater than that of 2U 0900–40 (8.96 day).

The delay between supernova explosion and activity of the X-ray source is sufficient to explain why no supernova remnant is seen associated with the X-ray sources, and it is interesting that if this evolutionary model is correct then there should be X-ray binaries with periods in the range 10 to 150 day. Van den Heuvel points specifically to the source 2U 0525–06, which is relatively weak ($\sim 10^{33}$ erg s^{-1}) and has been identified with the spectroscopic binary θ^2 Orionis, which has a period of 21 day and in which the primary is not yet filling its Roche lobe.

The model is certainly attractive qualitatively, but the evolution of massive close binaries which engage in large scale mass transfer is far from being well understood quantitatively.