galactic nuclei and quasars may involve a scaled-up version of the same processes as occur in pulsars and compact X-ray sources. Specific ideas along these lines were presented by Drs J. P. Ostriker (Princeton University) and R. D. Blandford (University of Cambridge). But data on these faint extragalactic objects accumulate relatively slowly although remarkably detailed new spectra of some high redshift quasars were reported by Dr P. A. Strittmatter (University of Arizona). There seems much less chance of achieving any real understanding of these extragalactic objects in the near future than in the case of pulsars and X-ray binaries. At the meeting Professor G. Burbidge (University of California, San Diego) reiterated his doubts about whether the quasars are at cosmological distances, and one suspects that this level of basic scepticism may be just as legitimate in five years' time as it is now.

It was perhaps not surprising that this meeting raised more questions than it answered. The nature of these questions is such that their solution demands the collective expertise of physicists and astronomers with a broad range of skills. They also require data, or even co-ordinated observations, spanning the whole accessible electromagnetic spectrum. Studies of these enigmatic compact objects have thus already helped both to stimulate collaboration between astronomers using different observational techniques, and to incorporate astrophysics and relativity more fully in the mainstream of contemporary physics.

NUCLEAR PHYSICS

Potential Ambiguities

from our Nuclear Structure Correspondent

SEVERAL recent investigations have shown that the ambiguities in the optical potentials describing the elastic scattering of helions and alpha particles by nuclei disappear at high enough energies, usually above about 100 MeV. A semi-classical analysis by Goldberg and Smith (*Phys. Rev. Lett.*, **29**, 500 ; 1972) showed that this can be understood in terms of the maximum (or critical) scattering angle θ_c. The ambiguity is only resolved if the differential cross-section is known for angles greater than θ_c. The critical angle decreases as the energy increases, so that it only becomes possible to resolve the ambiguity above a critical energy, provided the cross-section is measured to large enough angles. The critical angle also increases with the nuclear mass, A, so that it requires a higher energy to resolve the ambiguity for heavy nuclei than it does for light nuclei (see *Nature phys. Sci.*, **239**, 66 ; 1972).

Further insight into this question has now been obtained by the quantum-mechanical analysis of Goldberg, Smith,

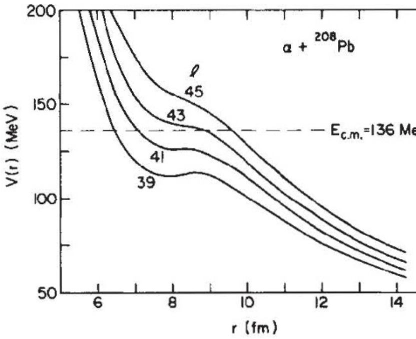

Fig. 1 Effective potentials for the elastic scattering of alpha particles by ^{208}Pb for values of l around 43.

Pugh, Roos and Wall (*Phys. Rev.*, **C7**, 1938 ; 1973). They examine the behaviour of the phase shifts for each partial wave as the incident energy changes, and find that it changes in character above a critical energy E_c ; at energies less than E_c the ambiguities occur, but for higher energies they are extinguished.

To see how this comes about, recall that the differential cross-section may be expressed as a function of the phase shifts so that ambiguous potentials must give very nearly the same phase shifts for all the partial waves that contribute to the scattering. But a phase shift is an angle, so increasing or decreasing it by any integral multiple of π does not affect the cross-section. Thus if all the phase shifts below a critical value l_c of the orbital angular momentum increase by $n\pi$ the ambiguity can occur.

This can happen for helion and alpha-particle scattering, as shown in Fig. 1. The total effective potential $V(r)$ acting on the incident particle of orbital angular momentum l is the sum of the nuclear potential, the electrostatic or Coulomb potential and the centrifugal potential $l(l+1)/r^2$ and this is shown as a function of r for several values of l for alpha particles on ^{208}Pb. These particles are strongly absorbed, so the scattering is essentially determined by the potential beyond the classical turning point defined by the condition that the incident energy equals $V(r)$. Now if the position of the turning point is regarded as a function of incident energy for different values of l, it can be seen from Fig. 1 that it moves inward suddenly at an energy corresponding to the triple point at which the minimum in $V_l(r)$ disappears. This sudden movement of the classical turning point at a critical value of l allows the phase shift to increase by $n\pi$ and hence gives rise to potential ambiguities.

The connexion between this sudden movement and the ambiguities is shown in Fig. 2. Here several different potentials all giving essentially the same differential cross-section are plotted as a function of radial distance for the critical partial wave with $l=43$. For each potential, the turning point moves in suddenly by amounts corresponding to phase shift increases of π, 2π and 3π. The ambiguities persist for all values of $l<l_c$, but at energies higher than E_c they do not arise, because there is no sudden dip in the effective potential and hence no sudden inward movement of the turning point. For energies less than E_c the ambiguities therefore occur in all partial waves, and thus in the potential as a whole, whereas for energies greater than E_c they do not occur in the higher partial waves. It is not possible in the latter case to find a potential that reproduces both the smooth variation for the higher partial waves and the $n\pi$ increase in the phase shifts for the lower partial waves, and so the potential is unique. It is thus

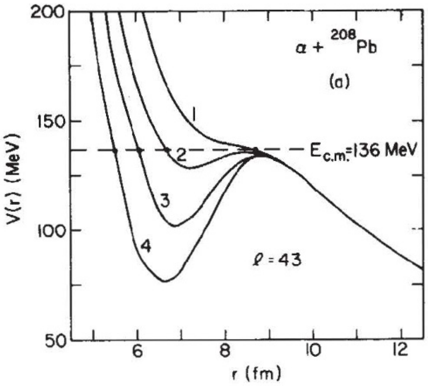

Fig. 2 Effective potentials for the elastic scattering of alpha particles by ^{208}Pb for $l=43$ only. Each of these potentials gives the same scattering, showing that the phase shifts differ by $n\pi$.

possible to understand why the potentials show ambiguities at low energies but not at high energies, and to relate the critical energy to the form of the effective potential.

Correction

IN the News and Views article "Receptor Function" (*Nature*, **244**, 253 ; 1973), the penultimate sentence in the third paragraph should read "Moreover, during successive ACh applications, the toxin becomes completely effective only after the first contact with ACh, suggesting that its action is dependent on an initial binding of ACh at the receptor." In the published version the word "effective" unfortunately appeared as "ineffective".