menon at perihelion. The erosive power of the wind-borne dusts is impressive enough to lend credence to the radar observations from Earth which suggest that large areas of Mars are covered by thick layers of dust and would not form easy landing grounds for vehicles such as Viking. Furthermore, the streaks of light and dark coloured dust which lie in the wind shadows of many of the craters suggest that the dust has a two component structure, as well as providing an insight into the variations of the wind. Thus, it now seems almost certain that the change in shape of the dark splotches on Mars is a result of the movement of light coloured dust over the darker dust; the once favoured idea that the sometimes dramatic growth of these dark areas could be attributed to plant growth now seems untenable.

But if the exobiologists have suffered a disappointment in this regard, Sagan's other news more than made up for it. This centred on the presence of the remarkable sinuous channels which so clearly suggest the presence, at sometimes in the past, of a flowing, low viscosity liquid. The channels are concentrated near the equator suggesting that the liquid in question must be one which can exist, at times, only in that part of the planet. Only one possible liquid fits the bill—water can flow in the equatorial regions of Mars if the planet's temperature is increased slightly. A 15% increase in the heat absorbed at the poles of Mars would produce a self sustaining temperature change, because the release of carbon dioxide would increase the atmospheric pressure, making the climatic circulation which carries warm air from the equator to the poles more efficient, and preventing the CO_2 caps from reforming.

This sort of increase in absorption is by no means impossible. Sagan listed four possibilities:

- Changes in the heat produced by the Sun. This has interesting astrophysical implications which are discussed by Sagan and Young in a letter on page 459 of this issue of *Nature*.
- Changes in the obliquity of the planet's axis to at least 28°. This is consistent with an independent suggestion from planetary astronomers that the obliquity of Mars may vary, up to 34°, with a period of some millions of years.
- Polar wandering, by which the CO_2 ice could be moved into the warmer parts of the planet.
- A decrease in the albedo of the CO_2 ice by only 3%, lasting for at least 100 years.

The last idea is perhaps the most immediately attractive because the albedo of the Martian dust is only about one third of the 75% albedo of the present polar caps, and there is no doubt that large quantities of dust are frequently stirred up in the Martian atmosphere.

Mars today, then, may be in a temporary ice age. At other times, the planet may be warm enough for running water to flow near the equator, although this would be associated with melting of a permafrost layer rather than rainfall. Obviously, this raises the prospect that some form of life could evolve during the warm spells, and even that spores would survive through the ice ages to await the next warm period. As Sagan pointed out, spores can survive for very long periods on Earth, where there has hardly been the same kind of evolutionary pressure that similar organisms would experience on Mars. Such spores are triggered into activity by the presence of water, and two of the experiments on the Viking landers involve the addition of water to samples brought into the spacecraft. That prospect should certainly rouse still further interest in the Viking missions.

NUCLEAR PHYSICS

Neutrino Interactions

from a Correspondent

THE beauty of the parton model of subnuclear matter which was introduced by Feynman is its simplicity. A solid state physicist sees atoms as point-like structures in his solid; as physicists probe further the atoms are seen to have smaller point-like nuclei surrounded by electrons; on closer examination still, nuclei are found to consist of protons and neutrons bound together by the nuclear force. Then the proton and neutron are found to be composite structures themselves with point-like structures within them called partons. In the simplest form of the model these are identified with the three quarks which describe the strong interaction symmetry SU3.

The predictions of the model are beautifully described in Feynman's lecture note volume *Photon-Hadron Interactions* (Benjamin, New York). The model was constructed to describe the deep inelastic electron scattering measured at the Stanford Linear Accelerator Center (SLAC), which revealed point-like structures possessing spin inside the proton.

New data have now been presented, some of which confirm the model, some which tend to contradict it, and all of which whet the appetite for more information.

At the National Accelerator Laboratory (NAL) at Batavia a neutrino beam has been produced from the 400 GeV proton beam. In a recent *Physical Review Letters* (**30**, 1084; 1973) the first results are presented of events produced by neutrinos in spark chambers. Events with a transfer of four momentum to the nucleon of 100 $(\mathrm{GeV}/c)^2$ are observed, corresponding to distances smaller than 10^{-15} cm; at this distance the interacting structure still appears to be a point; the number of events caused by antineutrinos is one-third of the number caused by neutrinos, in agreement with low energy data and the simple model. This is stretching the applicability of the model to smaller distances than before, and opens up a new field of physics of which more will be heard—neutrino spectroscopy.

At the Cambridge Electron Accelerator (CEA), experiments with electron-positron colliding beams have been in progress for more than a year. A recent report was given at the Washington meeting of the American Physical Society, and is soon to be published in part in *Physical Review Letters*. As has been already observed at Frascati in Italy, there is a large probability for producing events with many hadrons in the final state. According to the simple parton model, these hadrons are produced with an intermediate state of a parton-antiparton pair. Partons, if they are quarks, have spin quantum number of $\frac{1}{2}$, and the cross-section is therefore related to the cross-section for producing point-like, spin $\frac{1}{2}$, muons, by the relationship $R=\Sigma q_i^2$; where q_i is the charge of the ith parton. Because the charges on the quarks are $\frac{1}{3}$, $\frac{1}{3}$ and $\frac{2}{3}$, $R=\frac{2}{3}$. Experimentally, Frascati scientists already found $R\approx 1$, but now at CEA it is definitely confirmed that $R=4.6\pm 1.1$ at $q^2=16$ $(\mathrm{GeV}/c)^2$, possibly rising to 7 ± 3 at $q^2=25$ $(\mathrm{GeV}/c)^2$.

The parton model can be modified by assuming "sets" of quarks. The first modification allows "coloured" quarks (red, white and blue) and $R=2$. But this is not enough, and deeper modifications seem necessary which may destroy the model's simplicity—and will certainly change Feynman's book.

The model can also be tested by more precise measurements in a known region. Detailed measurements on the ratio of (e, p) to (e, d) scattering have been made at SLAC, and are also described in *Physical Review Letters* (**30**, 1087; 1973). These are interpreted as a ratio of (e, p) to (e, n) scattering and the neutron structure can therefore be derived. The neutron and proton, having different charges, are composed of different quarks, so that the experiment is sensitive to these details. A lower bound of 0.25 is imposed on σ_n/σ_p by the parton model. The data show that this is approached at large values of a variable $x=q^2/2MV$, and this is very hard for the simple theory to describe. One should, however, probably only expect the simple theory to describe gross features, and should expect precise experiments to show deviations.