tions suggest that the steep density gradient inside a globular cluster ensures that, for 47 Tuc at least, contributions to the total line profile in the line of sight from stars perturbed by the black hole and those unaffected by it should be roughly comparable.

The technological advances utilized by Weber in his search for gravitational radiation make this a plausible alternative means to observe black holes. With two revolving black holes at the centre of a globular cluster, Wyller shows that the rate of gravitational radiation can be much higher than that expected from other phenomena, both in the Earth mode frequency (1 cycle per hour) and higher frequencies up to ~ 1 cycle per second. Again treating 47 Tuc in detail, he predicts a flux at the Earth of $3.7 \times 10^5 \text{ erg cm}^{-2} \text{ s}^{-1}$, compared with $3 \times 10^{-5} \text{ erg cm}^{-2} \text{ s}^{-1}$ for the flux from a white dwarf pair rotating every 100 s at a distance of 100 pc from the Earth. Even more pronounced effects might arise from the galaxy centre type of black hole discussed by Lynden-Bell and others.

Ap STARS

Anomalous through Diffusion

from our Observatories Correspondent

THE suggestion that the composition anomalies in the spectra of Ap stars have resulted from diffusion in the surface layers will be greeted with interest by students of these peculiar stars (G. Michaud, *Astrophys. J.*, **160**, 641; 1970). Ap stars are characterized by abnormally strong lines of certain elements, particularly silicon, manganese, chromium, strontium and the rare earths, while other elements—notably helium, oxygen and carbon—have abnormally weak lines. Known for sixty years, Ap stars constitute about twenty per cent of all main sequence stars with effective surface temperatures between about 8,000 K and 20,000 K, and are only found in this range. There is, however, no widely accepted theoretical understanding of their properties.

In the early 1950s, H. W. Babcock found that Ap stars had large surface magnetic fields, typically between 1 and 10 kgauss, and as high as 34 kgauss in one case. He found that the fields often varied, on a time scale ranging from days to years. Later work by Babcock and G. W. Preston produced evidence that the variations are periodic, that the period is the rotation period of the star and that the axis of the magnetic field (usually not a simple dipole) is inclined to the rotation axis. Other variations in the spectra of Ap stars have led to the idea of localized patches of abnormal composition on their surfaces.

The anomalies in composition are very pronounced and during the past fifteen years spectroscopic analyses have demonstrated correlations between the behaviour of certain elements. For example, in some Ap stars the rare earth elements are overabundant by factors of about 10,000, while oxygen is deficient by a factor of about 100. There is also evidence that the character of the abnormal compositions is related to the surface temperature. For example, stars characterized by an abnormally high abundance of Mn are only found with surface temperatures of about 12,000 K.

Suggesting that the composition anomalies in the spectra of Ap stars have resulted from diffusion in the surface layers, Michaud adopts the view that the large

magnetic fields, the origin of which he does not consider, stably stratify the outer layer against mass motions such as convection. (An effect of this kind can be seen in sunspots where the magnetic fields damp down the solar granulation pattern.)

Hydrogen provides the bulk of the material in a stellar atmosphere. In a stably stratified atmosphere heavier elements diffuse downward under the gravitational field of the star. Michaud shows that the time scale for this gravitational settling is only 10^4 years, much less than the 10^8 years which the star spends in the main sequence. The tendency to sink is opposed by radiation pressure, however. This may act at the discrete frequencies of spectral absorption lines or in the photoionization continuum of any particular element. Whether or not the levitation due to radiation pressure wins over the gravitational settling depends on the temperature of the star and the details of the atomic spectrum of a particular ion. Thus an element may sink at one temperature when it is neutral and be pushed up at another temperature at which it is ionized.

Michaud has calculated the expected behaviour of several elements as a function of temperature, and found in many cases a satisfactory agreement with observation. In particular, he explains why stars with an excess of Mn are found with surface temperatures of about 12,000 K. But Michaud's diffusion mechanism may not be the full story. Spectroscopists have found lines of very heavy elements—mercury, platinum, osmium and perhaps even uranium—in some Ap stars, and there is evidence that the isotopic compositions of some of these elements are abnormal, in the sense that the neutron-rich isotopes are overabundant compared with terrestrial samples. This could not be attributed to atomic diffusion and would point to a nuclear origin for the composition anomalies of Ap stars. Specific nuclear theories, proposed by Hoyle, Fowler and the Burbidges, had some unsatisfactory features but no doubt the whole situation will be reassessed in the light of these new developments.

OCEANS

New Crustal Layer

from our Geomagnetism Correspondent

It is generally accepted that the lowest layer of the Earth's oceanic crust, immediately above the Mohorovičić discontinuity, has a seismic velocity of about 6.8 km s^{-1} . This is the crustal layer with the highest velocity, and contrasts with the uppermost layer of the mantle which has a velocity greater than 8.0 km s^{-1} . Velocities between these figures are not known; a layer of seismic velocity $7.0\text{--}7.5 \text{ km s}^{-1}$ is a feature of mid-oceanic ridges, some ocean margin regions and certain trenches, but velocities in this range have not been regarded as typical of ocean basin structure.

It now looks as if this view must be amended. Maynard (*Science*, **168**, 120; 1970) has produced unequivocal evidence that a basal crustal layer with velocities in the range $6.9\text{--}7.6 \text{ km s}^{-1}$ (average, 7.3 km s^{-1}) exists below the Pacific Ocean in the region between the Marshall and Hawaiian Islands. Refraction seismology leaves no doubt that the new layer exists in this region—and its extent (1,000 km) and thickness (several kilometres) suggest that it is probably widespread throughout the South and Central Pacific.