splat-cooled or coevaporated films (including the contentious question of whether resistivity ratios can be used to assess reliably the extent of metastable solubility).

GAMMA RAYS

Confidence Restored

by our Astronomy Correspondent

ONE may be forgiven for thinking that gamma ray astronomy is proving the least rewarding of the new astronomies, but at last quite a solid body of evidence is building up to support the claim that an extraterrestrial source of gamma rays is being observed. The breakthrough was provided by a detector in the third Orbiting Solar Observatory, which picked up high energy gamma rays (greater than 100 MeV) coming from the galactic plane, and especially strongly from the galactic centre (Clark, Garmire and Kraushaar, *Astrophys. J. Lett.*, **153**, L203; 1968). But understandable reserve has prevented hats being thrown in the air until verification was produced, especially after balloon experiments by the Case Western Reserve–University of Melbourne group cast doubt on the reality of the OSO 3 source (Frye *et al.*, *Nature*, **223**, 1320; 1969). Confusion over the OSO 3 calibration which finally resulted in a downgrading by a factor of three in the claimed intensity has not helped to inspire confidence. A report from Fichtel's group at the Goddard Space Flight Center should set the seal on the 1968 result, however (*Astrophys. J. Lett.*, **161**, L157; 1970).

During a balloon flight of a spark chamber that was being developed for use in the Small Astronomy Satellite, Kniffen and Fichtel picked up gamma rays coming from the galactic centre at an intensity corresponding to the revised OSO 3 estimate. The indications are that the origin of the gamma rays is in high energy collisions between cosmic ray protons and protons in the interstellar gas. Neutral pions produced in the collisions decay into gamma ray photons, having a flattish spectrum at these energies, a spectrum which seems to be indicated by a comparison of the intensities measured by Kniffen and Fichtel above 50 MeV and above 100 MeV. According to theoretical calculations there should also be a small contribution from bremsstrahlung by cosmic ray electrons. But it is too early yet to rule out the alternative explanation that cosmic ray electrons produce Compton scattering of the anomalously high infrared background radiation that has been recorded—questionably—during the past few years.

It is disappointing that Kniffen and Fichtel found no sign of the point source of gamma rays in Sagittarius reported by Frye *et al.* last year, but people will not be mortified. The evidence was never as solid as for the galactic source, and in any case, now that X-ray stars have been found to come and go it is no longer bad form to get round the problem by suggesting that gamma ray sources are also variable. The non-detection of the OSO 3 galactic source by Frye *et al.* remains a problem, however.

But the greatest disappointment remains the failure to detect gamma rays from the Crab Nebula—astronomy's *Escherichia coli*—against expectations that there should be a measurable source. The flux from the galactic centre, on the other hand, has turned out to be a few times more than predicted. From a balloon experiment such as that by Fichtel's group in which a large background of atmospheric radiation has to be subtracted, next to nothing can be deciphered about the second component reported in 1968 by Clark, Garmire and Kraushaar, an isotropic flux of gamma rays which seems to be present in the OSO 3 data. More satellite experiments will have to be carried out before the nature and indeed the existence of the isotropic background can be made more definite. With gamma ray astronomy now in the post-natal state, what are needed are detectors with large surface areas to be exposed for long times. This is a goal for the large lifting capability now available to the Americans.

EARTH'S MANTLE

Gravity and Global Tectonics

from our Geomagnetism Correspondent

MANY people have remarked on the correlations between certain anomalies in the geoid and surface features of the Earth—large negative anomalies, for example, seem to be associated with the deeper parts of the ocean, especially the ocean margin trenches. The problem with this type of generalization is that the low order harmonics of the geoid, which are the strongest, are much more likely to be associated with features in the lower mantle than tectonic features close to the Earth's surface. Thus unless very high harmonics are included in the geoid determination, the significance of the correlations is bound to remain in dispute.

But recently, Gaposhkin and Lambeck have made an improved determination of the Earth's gravity field (so far unpublished) from satellite data and terrestrial gravimetry, which contains spherical harmonic components of the potential complete to degree 16, and which thus gives a resolution of about 11° or 1,200 km. This has enabled Kaula (*Science*, **169**, 982; 1970) to show the Earth's gravity anomalies in much finer detail than before and to relate them more closely to the Earth's tectonic features and processes in the upper mantle.

The most interesting point to emerge from Kaula's analysis is that both ocean rises and island arc-trench systems are clearly associated with high positive gravity anomalies, which means that both types of region contain excess mass. Because excess mass anomalies can only be created by mass transfer, it seems natural to look for the source of the anomalies in terms of upper mantle convection processes—movement of the asthenosphere and the resulting lithospheric motion. But if, as seems to be the case, asthenospheric flow is essentially steady state and the moving material incompressible, it follows that any mass transfer cannot be a once-and-for-all phenomenon. What is required is a process which maintains a mass excess in particular regions of the overall flowing pattern.

Kaula lists five ways in which this could occur—the accumulation of material at the surface, the replacement of less dense by more dense material at an interior interface, transition to a denser phase, thermal contraction and petrological fractionation by which a less dense component is separated from the material before it enters the relevant region. As Kaula points out, however, the precise relationship between gravity anomalies and the flow system depends critically on the boundary conditions. If the upper boundary is fixed, an upwelling current such as that at a mid-oceanic ridge will produce a negative gravity anomaly because