decreases rapidly as the density increases The sensitivity of the entropy of the spin system to density can be observed by measuring the pressure as a function of temperature for a fixed volume of the sample, using temperatures from 0.02 K to 0.08 K, far above the antiferromagnetic ordering temperature of a few millidegrees. These measurements have been carried out in the presence of a large magnetic field, and a recent article by L. I. Zane (*Phys. Rev. Lett.*, **28**, 420 ; 1972) contains an analysis of some of these results.

If only nearest neighbour exchange were important a detailed fit to the experimental results should be obtained. The spin one-half Heisenberg model with nearest neighbour exchange has been studied in considerable detail, and more terms of the high temperature perturbation series for the thermodynamic properties of the spin system have been calculated than should be needed. In fact the fit is poor, and it seems that other exchanges must occur. Theoretical estimates have suggested that three-atom exchange should be the next most important process. Whereas two-atom exchange favours antiparallel spins, three-atom exchange favours parallel spins. The most important conclusion of Zane's article is that the fit to the experimental results can be greatly improved by including a three-atom exchange term whose strength is about 5 per cent of the strength of the two-atom exchange. The opposite sign of the exchange constant associated with such a term is said to be the most important feature for improving the fit. This should raise the temperature of the transition to the antiferromagnetic state.

As more detailed experimental results become available this kind of analysis can be carried further. It can only be successful if more complicated exchange processes occur with considerably lower probability than the simpler processes. Four particle exchange must be represented by a spin Hamiltonian which includes quartic terms, whereas two and three particle exchange is represented by terms quadratic in the spin variables.

NP 0532 (Edward Phillips)

Giant Pulses

OPTICAL pulses from the pulsar in the Crab Nebula are more regular in their behaviour than might be expected from a study of the radio pulses. This result is reported in the current issue of *Astrophysical Journal Letters* by P. Horowitz of Harvard University and C. Papaliolis and N. P. Carleton of the Smithsonian Astrophysical Observatory and Harvard University, who were inspired by the variability that the Crab pulsar (NP 0532) shows at radio frequencies to carry out a long term study of the variability in the optical spectrum (**172**, L51; 1972).

In the radio spectrum, for example, the Crab pulsar occasionally emits pulses which can be up to three orders of magnitude stronger than the average and which occur several times per hour. It was these giant pulses that led to the detection of the Crab pulsar.

To begin with, they report a two-hour sequence of observations in which a photomultiplier was used to measure the optical emission during successive peaks of the pulse train, the output of the photomultiplier being recorded digitally on tape. An analysis of the tape showed that the photomultiplier counts fit a Poisson distribution, and there was no indication of the occurrence of giant pulses, even though previous observations suggest that several giant pulses would have occurred in the radio emission during the duration of the observing period.

To demonstrate the overall constancy of the optical pulses, the Harvard group obtained an average light curve showing the main pulse and the interpulse based on observations during ten nights during the 1969–70 observing season, and a second average light curve from observations during 1970–71. Subtraction of the two curves showed that there is no detectable difference between the two curves, and the Harvard group report that the same result has been obtained from observations during the most recent observing season. This amazing stability in the long term also extends to shorter time scales—the Harvard group have compared long runs of data obtained in November and December last year, and again find no significant discrepancies between the curves. Their conclusion is that the optical light curve of the Crab pulsar looks the same whether averaged over one night or several years.

Cooperation in Astronomy at Meudon

M. Pollock & A. Bolton

from a Correspondent

THE inaugural meeting of the Astronomy and Astrophysics Division of the European Physical Society, attended by about 150 scientists from twelve countries, was held at Meudon, France, on February 3–5. The occasion also marked the official opening of the new Department of Fundamental Astrophysics at the Meudon Observatory.

During the session devoted to radio astronomy, H. van der Laan (Leiden Observatory) reviewed some studies of extragalactic objects made with the Westerbork array, which began observations in 1970. The high sensitivity of this telescope means that maps of extended sources can be obtained in which the radio contours are determined down to lower surface brightness than in previous maps. In many cases the maps show that double sources are joined to their parent object by faint "bridges", which often display much higher polarization than the rest of the source. Some oddly-shaped sources in clusters of galaxies (3C 465, for example) were interpreted by van der Laan as "galactic wakes", resulting from continuous or repeated ejection of radio-emitting plasma by galaxies moving at $\gtrsim 1{,}000$ km s^{-1} through the intergalactic gas. Radio emission has been detected from all Shapley-Ames galaxies brighter than the tenth magnitude.

Radio maps of nearby spiral galaxies (such as M51 and NGC 4268) have yielded some new insights into the origin of spiral structure which lend support to the "density wave" theory developed by C. L. Lin of MIT and his associates. Moreover, some observations of NGC 4268 suggest that the formation of spiral arms might be initiated by the ejection from the nucleus of two oppositely directed jets of gas in the plane of the galaxy. As the jets move outward they sweep up gas from the spinning disk, causing a density enhancement along a spiral track. This interpretation is based on continuum observations at 1,400 MHz, and it will be tested when 21 cm line studies (which are planned for the near future) map the velocity distribution of the gas in NGC 4268.

P. G. Mezger (University of Bonn) reviewed recent radio studies of interstellar gas in our galaxy. The gas is denser and cooler in spiral arms, so star formation will be concentrated in these regions. Mezger also discussed the evidence (from both hydrogen and molecular line observations) for an expanding ring of gas near the galactic centre.

Some problems of the final stages of stellar evolution and the formation of pulsars were discussed by B. Paczynski (Institute of Astronomy, Warsaw). If supernovae are triggered by the explosive ignition of carbon, calculations suggest that the star would be completely disrupted, leaving no remnant behind. Therefore if a neutron star is to be left behind, some process is needed for making the explosion less efficient. Paczynski suggested that, if the core were convective, cooling by the URCA process would be more effective than had been assumed previously. This would delay carbon ignition until the core had evolved to a denser and more tightly-bound configuration.