BAND STRUCTURE

Copper Leads the Way

by our Solid State Physics Correspondent

THE complicated band structure of the transition metals may at last be within reach of a solution if a new way of treating the *d* bands of copper proves to be as general as it seems. C. Y. Fong and M. L. Cohen (*Phys. Rev. Lett.*, **24**, 306; 1970) have replaced the tight binding approximation for the *d* bands by a non-local pseudopotential with an angular quantum number of 2, a technique first vented on the simpler case of potassium. By introducing parameters to respond to well known energy gaps in the zone they have obtained encouraging agreement with experiment and with other more fundamental calculations. Fong and Cohen urge that the more intractable transition metals should now be analysed.

Empirical pseudopotentials became fashionable in the wake of Abarenkov and Heine's work in 1964, which established the value of relaxing the pseudopotential formalism in favour of physically sensible model potentials. It was seen as a means of capitalizing on the weakness of the pseudopotential method, namely, the non-uniqueness of the potential due to the pseudo-wave-functions forming an overcomplete set. It soon became clear that a parametrized model could describe alkali metals with fair precision, as might be expected, but was not suitable for the transition metals, where the interaction between the *s* and *d* bands is strong. Attempts to use the tight binding approximation for the *d* bands and a pseudopotential for the *s* and *p* bands have proved of limited value, and so Fong and Cohen decided to dispense completely with the tight binding approximation in copper.

The pseudopotential they use was a square well with a simple damping term. The bands were constrained to fit experimental values at important symmetry points in the zone, and the band structure and the corresponding density of states were computed. Although only limited experimental results are available, the agreement produced by the model was good enough to make Fong and Cohen raise their sights to what may be achieved with other noble metals, and with the transition metals and their compounds, where the richer prizes lie.

There may be room, however, for an improved form of empirical pseudopotential for copper, based on the same approach to the *d* bands. Fong and Cohen could not use their model to reproduce some important details of the density of states curve, in particular the heights of the peaks, and although other calculations seem to have shown similar discrepancies there is no reason to suppose that such an unsophisticated potential should be the optimum form. But it is encouraging that this new representation of the *d* bands produced the sort of agreement that was needed to justify work on the transition metals.

VARIABLE STARS

Fast Pulses from White Dwarf

from our Cosmology Correspondent

FOLLOWING the discovery by A. U. Landolt that the dwarf star Haro-Luyten Taurus 76 has a rapid variability with a period of about 12 minutes (*Astrophys. J.*, **153**, 151; 1968), B. Warner and R. E. Nather have observed this object over the 1969 observing season, in an attempt to determine the cause of its variability. Their observations seem clearly to favour a pulsational rather than an eclipsing model for HL Tau-76, for the light curves which they have obtained greatly resemble those of dwarf novae of the SS Cygni type, although HL Tau-76 varies on a remarkably short time scale when compared with those of the accepted dwarf novae. Typical quasi-periods for dwarf novae are in the range 20–100 days (*Mon. Not. Roy. Astron. Soc.*, **147**, 21; 1970).

Several important features are clear from the observations of Warner and Nather, notably that although the amplitude variations of the light curves are quasi-periodic with a period of 12·44 minutes, the size of different peaks varies so much that occasionally odd peaks seem to be absent. The identification of this variation with that of dwarf novae must be tentative, if only because the period is so short. Warner and Nather point out that although the usual period–amplitude relation for these novae does not fit HL Tau-76 this is hardly surprising in view of the extrapolation required, which is more than three orders of magnitude. The most important question raised by this discovery must be that of a possible evolutionary sequence from models with periods of about 50 days to those with periods of a few minutes. Observational effects naturally favour the discovery of the longer period variations, but there will now be some incentive to look for variable stars with shorter periods.

HEARING

Auditory Illusions

from our Experimental Psychology Correspondent

OPTICAL illusions have fascinated psychologists for many years, not just as mere curiosities, but because when the visual system fails to interpret a stimulus correctly, this gives valuable clues as to the nature of perceptual mechanisms. Illusions and confusions of an auditory kind are very much rarer. But R. M. Warren has reported recently (*Science*, **167**, 329; 1970) that noises such as coughs can adequately replace speech sounds, with the hearer unaware that any speech sound is missing, and with the median subject in a group of twenty unable to locate the position of the cough to within five phonemes. (A phoneme is the smallest unit of speech that distinguishes one utterance from another.)

Warren's experiment involved erasing from magnetic tape 120 ms of speech sound, thus removing a complete phoneme from a word together with portions of the adjacent phonemes that might give transitional cues to the missing sound. Control subjects who were played the recording of a sentence with 120 ms of silence where the phoneme had been were easily able to notice that there was a sound missing, and correctly indicate on a written version of the sentence which part has been cut out. But nineteen experimental subjects hearing the sentence with a cough replacing the speech sound reported that all speech sounds were present. One subject reported a sound missing but chose the wrong one.

This is the third rather striking example of an auditory illusion discovered by Warren. With Gregory