at the discretion of the journal's editor. In addition, Huebner's letter has led our board of editors (of journals published by AIP and its member societies) at its March 1976 meeting to vote to permit this practice. However, our editorial staff cannot undertake the time-consuming task of supplying last page numbers if they are not given in the author's manuscript. So it will take time (years) until it becomes common practice in the journals.

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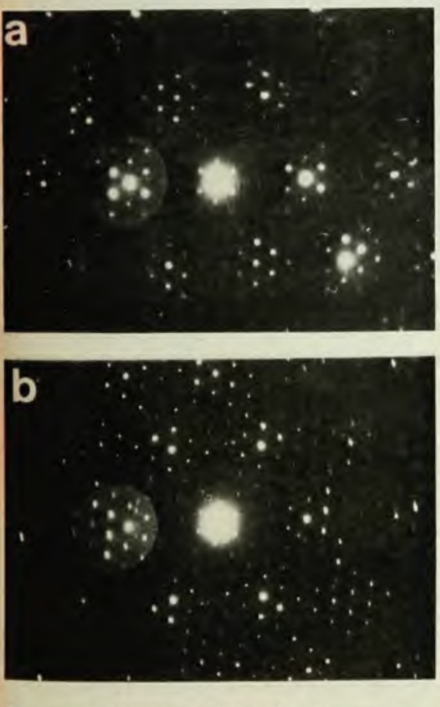
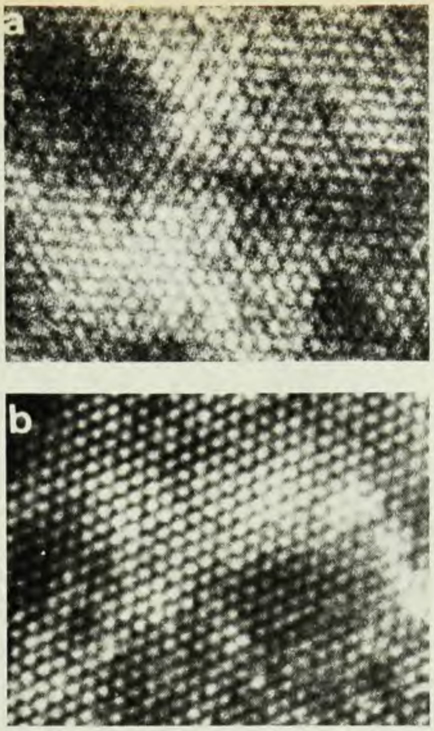
Charge density waves

Your June issue reported on recent experimental evidence for the existence of charge density waves, initially proposed, on theoretical grounds, by A. W. Overhauser for elemental crystals.

The evidence was derived from the observations of incommensurate satellite spots in electron diffraction patterns of the transition metal dichalcogenides: tantalum disulphide[1,2,3] and tantalum diselenide[2,3,4] and from neutron diffraction experiments.[5] On cooling, the incommensurate spots become part of a superlattice; two spots of the basic cadmium-iodide lattice related by a vector $3\mathbf{a}_1 + \mathbf{a}_2$ become separated by 13 superlattice interspot spacings.



Electron diffraction pattern of niobium ditelluride (a) exhibiting "irrational," incommensurate diffraction spots. The shadow of the aperature is visible (room temperature). Diffraction pattern of superlattice (b) at low temperature. Figure 1



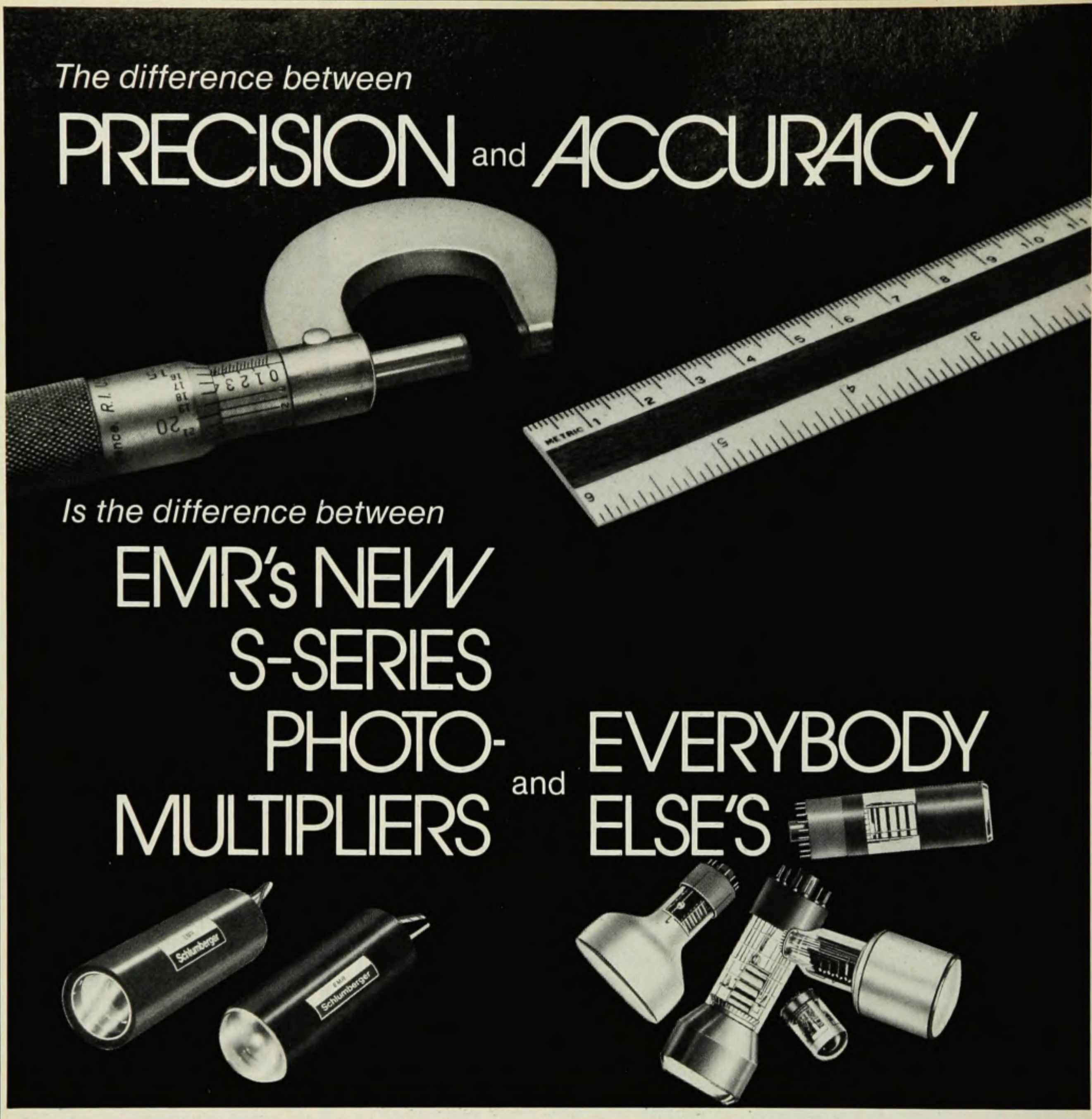
Incommensurate charge density waves (a) obtained from the diffraction pattern of figure 1a. Superlattice of charge density waves (b) corresponding to diffraction in 1b. Figure 2

It has now become possible to image directly the charge density waves in niobium and tantalum ditelluride in the electron microscope.[6] The room-temperature diffraction pattern of an octahedral polytype of niobium ditelluride is reproduced in figure 1a; at liquid-nitrogen temperature it becomes like figure 1b. At low temperature, the incommensurate waves derived from the diffraction pattern of figure 1a lock into the commensurate superlattice of figure 1b, exhibiting a geometry different from that found in tantalum disulfide and diselenide.

In both niobium and tantalum ditelluride, two spots, related by a vector $3\mathbf{a}_1 + 2\mathbf{a}_2$, are separated by 19 superlattice interspot spacings. Collecting the beam corresponding to one basic diffraction spot, together with all its satellite beams, due to the charge density waves, allows one to obtain images such as that shown in figure 2a for the incommensurate state and figure 2b for the superlattice state. These images are essentially the Fourier transforms of the diffraction patterns caused by the periodic charge distribution; they can be regarded as direct mappings of the charge density waves.

References

1. J. Van Landuyt, G. Van Tendeloo, S. Amelinckx, Phys. Stat. Sol. (a) **26,** 359 (1974) and **26,** 585 (1974).
2. J. A. Wilson, J. DiSalvo, S. Máhajan, Phys. Rev. Lett. **32,** 882 (1974); Adv. in Physics **24,** 117 (1975).



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3. P. M. Williams, G. S. Parry, C. B. Scruby, Phil. Mag. **29**, 695 (1974).

4. C. B. Scruby, P. M. Williams, G. S. Parry, Phil. Mag. **31**, 255 (1975).

5. D. C. Moncton, J. D. Axe, F. J. DiSalvo, Phys. Rev. Lett. **34**, 734 (1975).

6. J. Van Landuyt, G. Van Tendeloo, A. Amelinckx, Phys. Stat. Sol. (a) (to be published).

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Breeding with tokamaks

The articles on Soviet physics in your November issue are excellent. The authors and your staff merit congratulations for the informative, justifiably laudable and polite style in which the material is presented.

In view of worldwide emphasis on fusion as an ultimate and inexhaustible source of energy, the last paragraph in the fusion article merits the most serious attention. I believe it says that the Soviets are deferring their goal of constructing tokamak reactors because their technological feasibility is still not established and, even if such reactors were scientifically feasible, no one knows how to surmount the foreseeable materials and engineering difficulties. We have here a classic example of the fallacy of proceeding to engineering before the basic knowledge base has been built. As an interim goal the Soviets are now considering using tokamaks to produce neutrons for breeding Pu and/or U^{233}, because the difficulty of achieving the economic "break-even" point is thought to be less severe for this modality of operation.

Over the past several decades we have seen an interesting interplay between the US and USSR efforts in fusion. We invented stellarators and abandoned them only to see them assiduously pursued in the USSR. The Soviets invented tokamaks, are temporarily abandoning them as far as original goals are concerned, while we are pursuing them with great enthusiasm.

I think it might be a great loss were we to proceed into large-scale endeavors to breed fissionable material, with devices as uncertain and as difficult as tokamaks, if this occurred at the expense of performing the really basic research that is necessary at least to determine whether controlled fusion reactors are indeed feasible.

Before we follow the Soviet lead in the direction of tokamaks as "breeders," the following additional points are worth discussing.

Deuterium–tritium fusion reactors are attractive because they require much lower plasma temperatures than do D–D reactors, and because they can breed at least as much tritium as they consume.[1] However, you cannot use the same neutron for breeding Pu or U^{233}. You may have one or the other. A Pu atom is worth about 180 MeV, including two and one-half 1-MeV neutrons. (Also, 14-MeV neutrons interacting with U^{233} give rise to neutrons of average energy about 1 MeV.)[2] A tritium atom is worth about 18 MeV including one 14-MeV neutron. This looks like you can make a large profit by breeding Pu and then making up the tritium by irradiating Li in a reactor. However, there are some penalties. Fourteen-MeV neutrons can convert Li^7 into tritium[1] while 1-MeV neutrons cannot. They require, for tritium production, the much rarer isotope, Li^6.

If breeding fissionable material is to be the name of the game, would it not make sense to do this with D–D neutrons, which can be obtained (perhaps quite economically) from explosively driven fission–fusion devices? One thereby avoids both the high cost and high radioactivity associated with large tritium inventories. Our technology for underground nuclear explosions is far more advanced (it even works safely) than our CTR technology. Should we not at least be prepared to use that technology, to breed Pu and U^{233} in case all else fails?

Going one step further, since reactors will be required to utilize the fissionable material, however it is produced, how about building breeder reactors? We might even consider giving them French names, since those with French names appear to work.

References

1. L. Rosen, L. Stewart, Phys. Rev. **126**, 1150 (1972).

2. L. Rosen, L. Stewart, "Neutron Emission Probabilities from the Interaction 14-MeV Neutrons with Be, Ta, Bi, and U^{238}," Los Alamos Report No. 2111, January 1957.

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Improving peer review

Several years ago, on behalf of the Netherlands government, I studied review methods practiced by a number of US research agencies, including NSF, AEC, and NIH. Since NSF provided host facilities for me, it was inconvenient to concentrate most of my efforts on NSF itself. At the time I was impressed by the skill with which program officers especially in the physics section of NSF carried out their task. They were extremely well acquainted with their fields and had thorough methods of continuously finding new names to add to the list of future referees. If necessary, they made use of foreign specialists and in *their referee files* I hap-