Comment on "Speckle in the Diffraction Patterns of Hendricks-Teller and Icosahedral Glass Models"

In their interesting Letter,[1] Garg and Levine discuss speckle in the diffraction patterns of Hendricks-Teller and icosahedral glass models. The purpose of this Comment is to point out that diffraction speckle is not specific to these models, but is instead a general (though often unobservable) property of a wide range of disordered materials. Diffraction speckle in the calculated structure factors of simple metallic glass models has been previously discussed[2] and high-resolution scanning transmission microscope dark-field images of thin amorphous films have also been interpreted in terms of random interferences.[3] The standard speckle analysis[4] is constructed for the case of randomly placed atoms, but the phenomenon appears in amorphous materials with short-range order because the speckle due to the large number of distant uncorrelated atom pairs is comparable in size to the scattering contributions from the relatively small number of correlated close neighbors. As pointed out by Garg and Levine, speckle effects are not usually seen in x-ray and neutron-diffraction experiments because the k-space resolution width of typical experiments is much larger than $1/L$, where L is the sample size.[5]

It is instructive to discuss speckle within the context of structural uniqueness because the true structure factor of a given sample is sensitive not only to the "average" structure of the material but also to the detailed atomic arrangement in that particular sample and it is diffraction from (relatively) distant atom pairs that leads to speckle. The members of an ensemble of perfect crystals of a given structure are essentially identical; their diffraction patterns are therefore identical and there is no speckle in the structure factor. Each member of an ensemble of Hendricks-Teller, icosahedral glass or "normal" glass samples is, however, unique though all members of the ensemble were constructed with the same statistical law governing atomic positions. The diffraction pattern from each sample is therefore different and displays speckle since it includes random contributions from spatially uncorrelated distant atom pairs. Furthermore, since quasicrystalline samples with random phason strains must each have a different atomic arrangement in detail, it is to be expected that their true structure factors are unique and hence show speckle.

K. F. Ludwig, Jr.[(a)]
IBM Research Division
Thomas J. Watson Research Center
Yorktown Heights, New York 10598

Received 24 June 1988
PACS numbers: 61.10.Dp, 42.20.Ee, 61.40.+b

[(a)]Present address: Department of Physics, Boston University, Boston, MA 02215.

[1]A. Garg and D. Levine, Phys. Rev. Lett. **60**, 2160 (1988).
[2]R. Alben, G. S. Cargill, III, and J. Wenzel, Phys. Rev. B **13**, 835 (1976).
[3]P. Chaudhari, J. F. Graczyk, and H. P. Charbnau, Phys. Rev. Lett. **29**, 425 (1972).
[4]J. W. Goodman, in *Laser Speckle and Related Phenomena,* edited by J. C. Dainty (Springer-Verlag, Berlin, 1984), p. 9.
[5]The effect of k-space resolution on observed scattering patterns is profound; for instance, the Debye scattering formula is valid for a particular sample only in the limit of low (compared to $1/L$) resolution. Furthermore, simple manipulations of structure factors [cf. B. P. Dolgopolsky and W. L. Johnson, Phys. Lett. **94A**, 91 (1983)] may be mathematically valid yet produce misleading results if resolution effects are not considered.