Comment on "Direct Measurement of the Longitudinal Coherence Length of a Thermal Neutron Beam"

In a recent Letter, Kaiser, Werner, and George (KWG)[1] present a beautiful neutron interference experiment and claim to have observed *"the detailed longitudinal shape of a neutron wave packet."* It is shown here that the KWG experiment only confirmed the already known value of the incident-beam wave-number spread, σ_K, but did *not* supply any *new* information; i.e., it was simply an alternative way to measure the wave-number spread.

KWG have measured the contrast $[=(I_{max}-I_{min})/(I_{max}+I_{min})]$ as a function of the thickness D of an Al slab placed in one of the interferometer legs. They have interpreted the contrast loss as the result of a reduction in overlap between interfering wave packets due to the spatial shift induced by the Al slab. However, KWG have not made use of the fact that the loss of contrast is directly due to lack of beam monochromaticity via the wavelength dependency of the spatial shift [Eq. (6), Ref. 1]. This is done here. Neutrons with different wavelengths experience different phase shifts. The effect is substantial. For instance, when the conditions for I_{max} are met, i.e., neutrons of nominal wavelength $\lambda_0 = 1.268$ Å interfere in phase, neutrons with wavelengths only 1% off interfere—for $D = 1$ cm—almost in antiphase ($\Delta\varphi \approx 150°$).

The effective I_{max} (I_{min}) is calculated here exclusively by using formulas and numerical values from Ref. 1. From Eqs. (6) and (8) the contribution to the effective intensity of the neutrons of wavelength λ, when the I_{max} (I_{min}) conditions for the nominal wavelength λ_0 are met, is obtained. These contributions are then weighted with the neutron wavelength distribution (Gaussian, $\sigma_K = 0.0254$ Å^{-1})[1] and summed by integration upon λ, for various values of D. The resulting effective I_{max} and I_{min} values are used to calculate the contrast, plotted as a solid line in Fig. 1. Note that no adjustable parameter was used. The experimental points from Fig. 4 curve C of Ref. 1 are also plotted. (Their abscissa is shifted by $D = 0.07$ cm according to Ref. 1.) In spite of the apparent similarity between the solid line in Fig. 1 here and the corresponding one in Fig. 4 (curve C) of Ref. 1, they differ fundamentally. The curve in Fig. 1 here is calculated exclusively from equations and data [Eqs. (6) and (8) and σ_K] which were known *before* the KWG experiment was done. Thus, the excellent agreement with the data from the KWG experiment demonstrates that these data do not supply any new information. In contrast, curve C in Fig. 4 of Ref. 1 is simply a Gaussian fitted to the experimental points obtained from the KWG experiment. KWG use the full width at half maximum of this fitted Gaussian to obtain "new" information (first observation of "the detailed longitudinal shape of a neutron wave packet" and explicit verification of "the uncertainty relation for neutrons in longitudinal direction"). This is certainly at variance with the above conclusion.

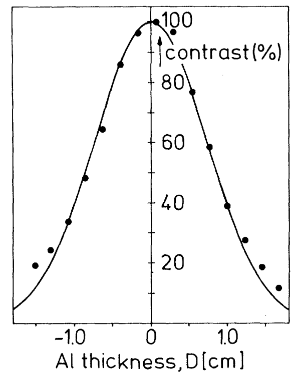

FIG. 1. Loss of contrast vs aluminum slab thickness D. The data points are taken from Fig. 4, curve C, Ref. 1. The theoretical loss of contrast (solid line) is due only to the phase-shift dependence on the wavelength of the neutrons, each described by a wave packet of infinite length. No adjustable parameter was used.

The summation of the intensity contribution of each individual neutron as done here accounts for the fact that the intensity pattern in interference experiments with particles with relative random phases is the result of the interference of each particle with itself.[2] The calculation leading to the solid line in Fig. 1 implicitly assumes that each particular neutron is represented by a single plane wave (wave packet of infinite length).

George Comsa
Institut für Grenzflachenforschung und Vakuumphysik der Kernforschungsanlage Jülich GmbH
D-5170 Jülich, Germany

Received 4 April 1983
PACS numbers: 03.65.Bz, 42.50.+q

[1]H. Kaiser, S. A. Werner, and E. A. George, Phys. Rev. Lett. 50, 560 (1983).
[2]L. I. Schiff, *Quantum Mechanics* (McGraw-Hill, New York, 1955), 2nd. ed., Chap. I.