Comment on "de Haas-van Alphen Effect and Fermi Surface of $YBa_2Cu_3O_{6.97}$"

In a recent paper Fowler *et al.* [1] claim to have observed the de Haas-van Alphen (dHvA) effect in oriented powders of Y-Ba-Cu-O using a 100-T flux compression system. They conclude that $YBa_2Cu_3O_{6.97}$ (YBCO) exhibits a Fermi surface which is consistent with LDA calculations and they proceed to estimate values for the mass renormalization λ that are unexceptional and in the range 1-4. These results are of importance since, if true, they would appear to confirm the existence of a conventional Fermi-liquid state. However, we believe that the results presented do not provide convincing evidence for the dHvA effect in YBCO.

dHvA effect oscillations of the magnetization are periodic in B^{-1} and, in a time-varying magnetic field, give rise to an induced voltage in a pickup coil surrounding the sample having the general form

$$V(B)=B\sum_{i,r}A_{i,r}(B,T)\cos\left(\frac{2\pi rF_i}{B}+\phi_{i,r}\right), \qquad (1)$$

in which F_i are the dHvA frequencies and rF_i their harmonics. $V(B)$ is sampled at equal intervals of time to generate N pairs of data points, $V(t_j),B(t_j)$, which may then be analyzed either in the time domain or with respect to B^{-1}, for which the respective Fourier transforms (not FFT's) are

$$V(f_k)=\left|\frac{1}{N}\sum_j W_jV(t_j)\exp(i2\pi f_kt_j)\right| \qquad (2)$$

and

$$V(F_k)=\left|\frac{1}{N}\sum_j W_jV(t_j)\exp[i2\pi F_kB^{-1}(t_j)]\right|, \qquad (3)$$

in which W is a window function.

We present in Fig. 1, curve *a*, the Fourier transform $V(F_k)$ of the experimental record given in Fowler *et al.* [1], showing that it consists of a large number of frequencies which are not obviously harmonically related. It is this Fourier transform $V(F_k)$ which corresponds directly to the voltages present in the measured signal, whereas the power spectral density given by Fowler *et al.*, which appears to be given approximately by $V^2(F_k)/F_k^2$, strongly emphasizes the low frequencies.

In analyzing their experimental data, Fowler *et al.* have assumed the presence of three dHvA base frequencies together with their harmonics. It is clear from an inspection of their paper that this assumption does not provide a good fit to the experimental data. The three features that are regarded by them as being the dHvA effect are indicated by arrows in Fig. 1. Of these, we find that the highest frequency, $\sim 3.5kT$, has a larger amplitude when the Fourier transform is taken in the time domain [$V(f)=32$ mV] than when taken with respect to B^{-1} [$V(F)=26$ mV], suggesting strongly that it is a time frequency rather than the dHvA effect. The amplitudes, frequencies, and even the presence of the lower two frequencies at $\sim 0.5kT$ and $\sim 0.75kT$ are sensitive to the choice of window function W which, for curve *a*, was taken as a constant over the data window. By using a Hanning window (see curve *b*) the low-frequency structure in $V(F_k)$ is drastically affected and the former peak at $\sim 0.75kT$ is no longer present. Thus, on the basis of inspection of the data from a single noisy experiment, one clearly cannot say whether all, some, or none of the structure in the Fourier transform $V(F_k)$ is the dHvA effect.

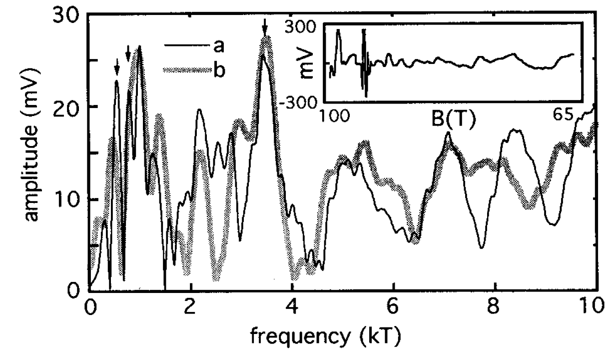

FIG. 1. Fourier transform $V(F_k)$ of the pickup coil signal (shown as an inset) recorded in the experiment discussed by Fowler *et al.* and reproduced in Fig. 1 of their paper [1]. The three arrows identify the three frequencies regarded by Fowler *et al.* as being the dHvA effect. For curve *a*, the window function W is a constant (equal to unity) over the data window, while for curve *b*, a Hanning window function is used.

Fowler *et al.* also make reference to other of their experiments which exhibit similar features. However, as is clear from the above remarks, these may all be artifacts of the experiment. What is required, in order to establish the existence of the dHvA effect, is a clear demonstration that reproducible signals exist which are periodic in B^{-1}. On the basis of the evidence given in the paper, we conclude that a convincing case for the observation of the dHvA effect in YBCO has not been made. It is common experience that type-II materials give rise to flux noise in rapidly changing magnetic fields.

We are grateful to Professor F. M. Mueller who, during a correspondence with us on this matter, made available to us the raw data of the experiment depicted in Fig. 1 of Fowler *et al.*, to which the accompanying Fourier transforms relate.

M. Springford, N. Harrison, P. Meeson, and P-A. Probst
H. H. Wills Physics Laboratory
University of Bristol
Bristol, BS8 1TL, United Kingdom

Received 26 March 1992
PACS numbers: 71.25.Hc, 07.55.+x, 74.60.−w

[1] C. M. Fowler, B. L. Freeman, W. L. Hults, J. C. King, F. M. Mueller, and J. L. Smith, Phys. Rev. Lett. **68**, 534 (1992).

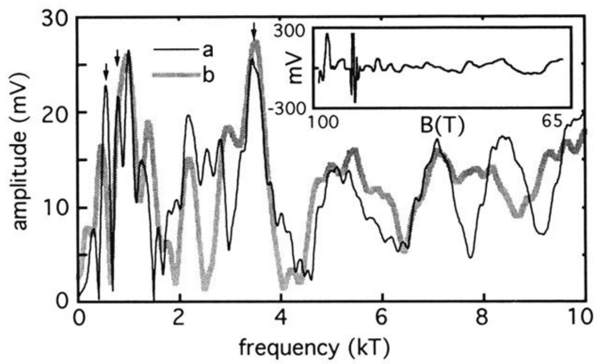

FIG. 1. Fourier transform $V(F_k)$ of the pickup coil signal (shown as an inset) recorded in the experiment discussed by Fowler *et al.* and reproduced in Fig. 1 of their paper [1]. The three arrows identify the three frequencies regarded by Fowler *et al.* as being the dHvA effect. For curve *a*, the window function W is a constant (equal to unity) over the data window, while for curve *b*, a Hanning window function is used.