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Authors

Challener, W A

Richards, P L

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FAR INFRARED OPTICAL PROPERTIES OF $NbSe_3$

W.A. Challener and P.L. Richards
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LBL-17293 Summary
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W.A. Challener and P.L. Richards

FAR INFRARED OPTICAL PROPERTIES OF NbSe₃

Department of Physics, University of California,
and Materials and Molecular Research Division,
Lawrence Berkeley Laboratory
Berkeley, California 94720, U.S.A.

NbSe₃ is a prototype for sliding charge density wave (CDW) systems. It undergoes independent and incommensurate CDW phase transitions at $T_1 = 145$ K, and $T_2 = 59$ K. At each transition a fraction of the free carriers present at room temperature condense into a CDW. The oscillator strength of the condensed carriers can appear in a low frequency pinned mode [1], a single-particle continuum above a CDW energy gap [2], and coupled CDW carrier-optical phonon modes (phase phonons) [3].

We have measured the far infrared reflectance of NbSe₃ and have used a Kramers-Kronig analysis to obtain the estimate of the frequency dependence of the conductivity, $\sigma_1(\omega)$ shown in Fig. 1(a). The qualitative features of the conductivity include many phonons which appear below T_2 , and a low frequency contribution from the free carriers and the pinned mode.

General arguments show that at 2 K a charge density (CDW) energy gap exists between 120 and 190 cm^{-1} , the relaxation time(s) of the free carriers and CDW pinned mode is $>3 \times 10^{-12}$ s, and the ratio of the free carrier concentration to band mass is $<2 \times 10^{20} \text{ cm}^{-3}/m_0$.

A detailed model fit to the conductivity shown in Fig. 1(b) reproduces the data very accurately. It gives estimates of carrier concentrations and relaxation times; electron-phonon coupling constants and the size of the CDW energy gap. When analyzing a limited data set from a very complicated physical system like NbSe₃, however, one cannot be entirely certain that all of the relevant physics is included in the model. As our knowledge about NbSe₃ increases, the fitting procedures used here may have to be modified. It seems clear, however, that the far infrared reflectance data will provide strong constraints to any proposed model.

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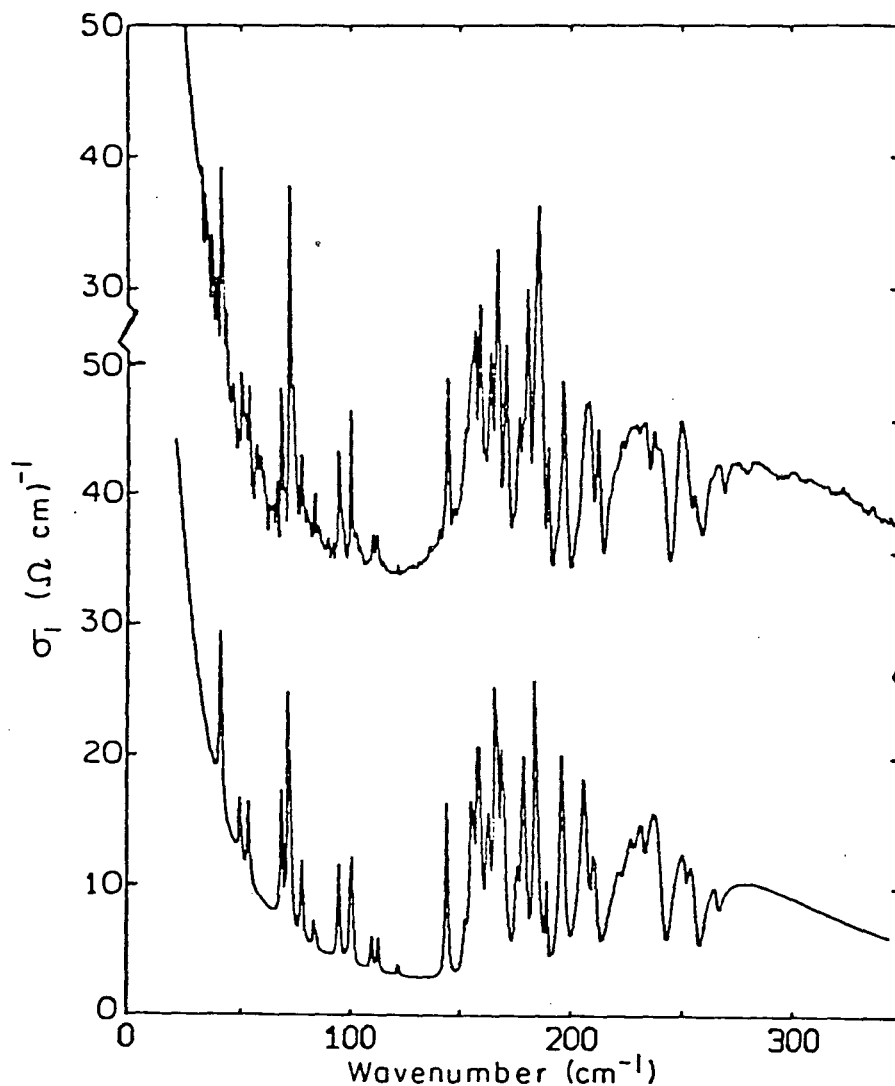


Figure 1. (a) Kramers-Kronig calculation of $\sigma_1(\omega)$ from the measured reflectance. (b) Model calculation of $\sigma_1(\omega)$ fitted to data.

References

1. J. Bardeen, Proceedings of the International School of Physics "Enrico Fermi" Varenna, Italy, July 4-6, 1983 (to be published); G. Gruner, A. Zettl, W.G. Clark, J. Bardeen, Phys. Rev. B24, 7247 (1981).
2. P.A. Lee, T.M. Rice, P.W. Anderson, Sol. St. Comm. 14, 703 (1974).
3. M.J. Rice, Phys. Rev. Lett. 37#1, 36 (1976).

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