Title
Far Infrared Optical Properties of NbSe3

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Summary

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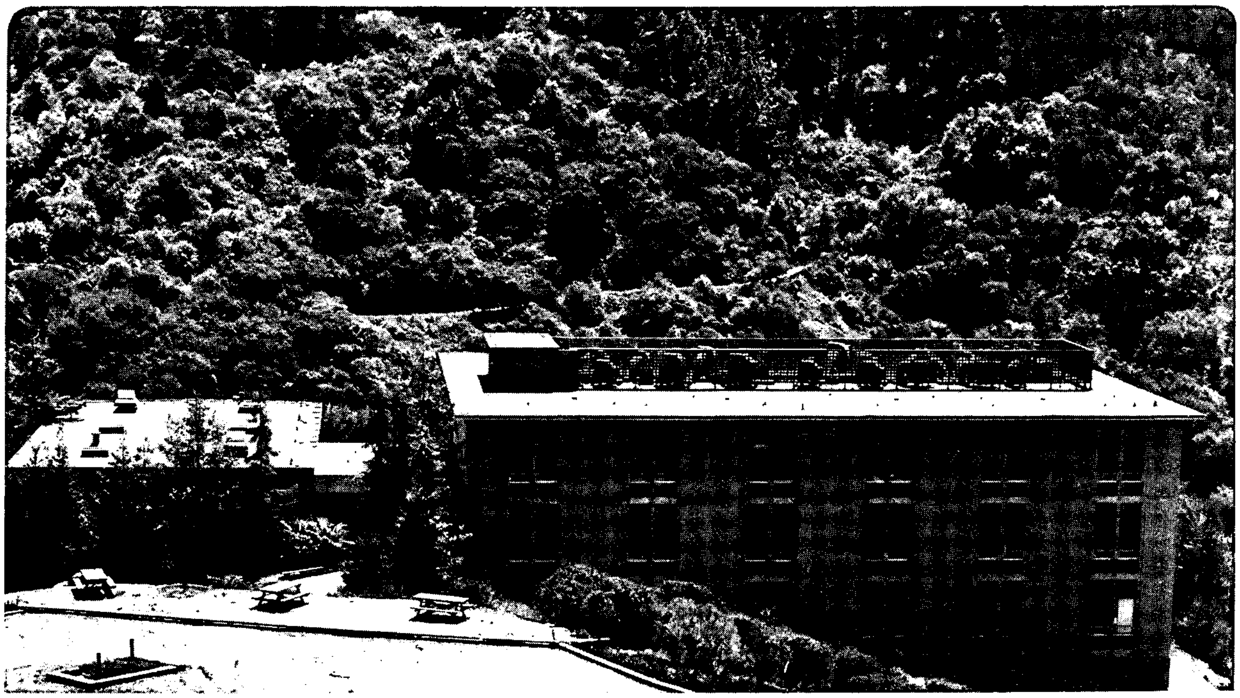

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FAR INFRARED OPTICAL PROPERTIES OF $NbSe_3$

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$NbSe_3$ 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 $NbSe_3$ 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 $>3\times10^{-12}$ s, and the ratio of the free carrier concentration to band mass is $<2\times10^{20}$ 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 $NbSe_3$, however, one cannot be entirely certain that all of the relevant physics is included in the model. As our knowledge about $NbSe_3$ 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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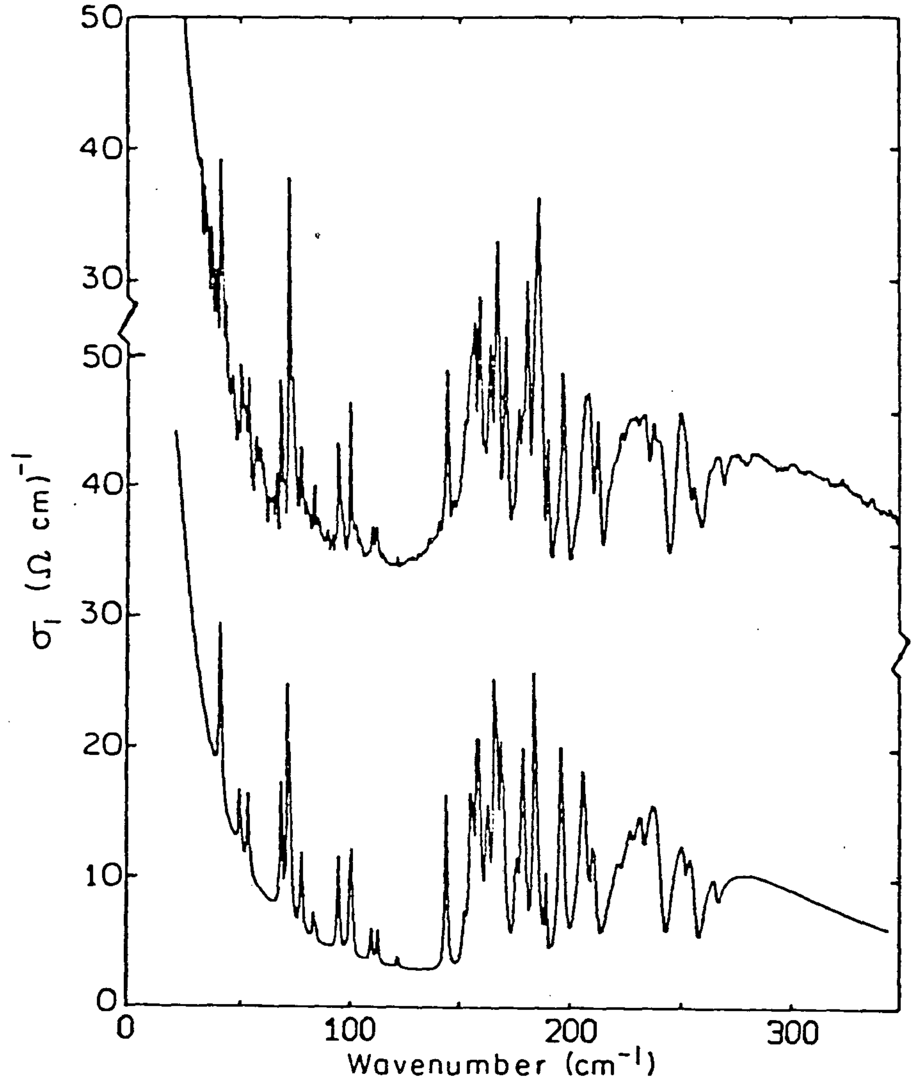

Figure 1. (a) Kramers-Kronig calculation of $\sigma_1(\omega)$ from the measured reflectance. (b) Model calculation of $\sigma_1(\omega)$ fitted to data.

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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