

Comment on "Resonant Microwave Absorption of Selected DNA Molecules" and "Observation of Low-Lying Raman Bands in DNA by Tandem Interferometry"

Two recent Letters have reported observations of excitations in double-helical DNA. If one looks at both, a pattern for the excitations emerges which is more apparent than one can get from looking at each paper separately. This pattern should be of interest to condensed-matter physicists.

The point I wish to emphasize from the first paper¹ is that one can get an unambiguous value for the lifetime and for the coherence length or mean free path of the acoustic excitations. Because the coherent fundamental mode was observed in a 948-base-pair segment the coherence length is at least that size. A traveling wave would have to make a back and forth transit for resonance and would have a mean free path of ≈ 2000 base pairs or ≈ 7000 Å at room temperature. This is for a system in dilute solution.

The second paper² deals with observations of optical modes. The material is fibers or films of DNA with heterogeneous base sequences rather than the identical cal strands in the sample for the microwave data. Because of this heterogeneity the observed bands are inhomogeneously broadened and lifetimes based on linewidth cannot be determined. However, there are qualitative estimates which indicate that the situation is not that different for these low-lying optical modes. The modes observed with (z,x) or (z,y) polarization scattering are circularly polarized waves of wavelength ten or eleven base pairs in the extended-zone scheme used. These modes show k conservation on scattering which implies coherence lengths of the order of the optical wavelength ≈ 0.5 μm or again several thousand base pairs.

An even better estimate of coherence length comes from examining the modes observed at 12 and 22 cm^{-1} . We calculate^{3,4} these two modes to be on the same character branch which is also the soft-mode branch. This is verified by the observation that both modes soften approaching conformation change.⁵ The 12- cm^{-1} mode is at zone center and the 22- cm^{-1} line is at wavelength of eleven base pairs. These positions

on the dispersion curve are verified by the observed scattering polarizations. For this dispersion to be expressed, on going from 22- cm^{-1} frequency at an eleven-base-pair wavelength to a 12- cm^{-1} frequency at infinite wavelength, large coherence length is needed. It is likely that this coherence length is of the order of thousands of base pairs as in the acoustic case.

The reason that these papers should be of interest to condensed matter physicists is that the low-lying vibrational modes of a long section of DNA helix are long-lived phonons of mean free path of thousands of angstroms propagating on an extended one-dimensional system. The conceptual framework that is appropriate is lattice dynamics. Lattice-dynamics calculations do predict the vibrational spectrum very well.⁴ Lattice-dynamics concepts and the tools for studying such modes are relatively unfamiliar to people in other disciplines.

It should be pointed out that the theoretical models do require long-range electrostaticlike interaction to fit the observations in DNA.⁶ It is therefore not inconsistent to have a soft-mode-mediated transition in a one-dimensional system representing DNA.

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