A nugget from FOCUS:

**Controlling atomic vibrations to isolate anharmonicity**

D. Fritz, E. Murray, J. Wahlstrand, S. Fahy and D. A. Reis

Researchers at FOCUS in collaboration with visiting scientist Stephen Fahy and his student Eamonn Murray from University College Cork are studying the effect of anharmonicity on extremely high amplitude vibrations (phonons) using the semimetal bismuth as a model system. When an ultrafast laser pulse interacts with the material exciting a large fraction of the valence electrons, the atoms suddenly find themselves far from equilibrium. This results in high amplitude coherent oscillations of the atoms about a new equilibrium position with a natural frequency dependent on the strength of the interatomic forces. At high enough amplitudes, we expect that the motion will become distorted (anharmonic) leading to an amplitude dependent frequency. Past experiments have been unable to unravel this effect from softening of the inter-atomic forces, which also affects the oscillation frequency.

In order to separate these effects, we use two laser pulses to excite the sample at different times. In analogy with pushing a child on a swing, if the second pulse comes at the right time, the vibration is enhanced. If the second pulse is purposely mistimed, the vibration is diminished. In this manner, we could study the effects of vibration amplitude on the frequency independent of all other dynamics of the system. The results were also compared with first principles theoretical calculations. In both instances, we show that weakening of the atomic bonds plays a much more important role than anharmonicity in the dynamics of the system. This is an important step in understanding the much more complex coupled dynamics of ultrafast laser excited materials.

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**Center for the Advancement of Frontiers in Optical Coherent and Ultrafast Science**

The University of Michigan and the University of Texas at Austin

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Controlling atomic vibrations to isolate anharmonicity

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Potential Energy vs. Carrier Concentration

optical probe of coherent motion:
two pump pulses control amplitude at fixed $n(t)$

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