**High-throughput first-principles phonon calculation and phonon database**

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First-principles phonon calculation has been popular in recent scientifc researches. In the harmonic appoximation, now we have enough computational hardware resource to achieve high-throughput phonon calculations for ~10,000 compounds [1-3]. However the high-throughput calculations are not a trivial task since we need a sophisticated workflow engine to systematically execute first-principles phonon calculations. Among workflow engines, AiiDA [4] and atomate [5] may be the most popular packages. A number of people are working to develop the workflow engines and a lot of efforts have been put into the development. These developlements are well organized on their github repositories that are open to everybody indeed. These workflow engines rely on many other software packages that are also expected to be robust. We have been contributing to them by providing crystal symmetry finder (spglib [6]) that is widely used in materials science. For the first-principles calculations to be run by the workflow engines, fortunately we have several realistic choices of DFT or DFPT plane-wave pseudopotential codes such as QUANTUM ESPRESSO, ABINIT, and VASP codes.

To achieve our phonon calculations [3], force constants were calculated in supercells with finite small atomic displacements (~0.03Å), where the initial crystal structures were obtained from the materials project [7]. This set of phonon calculations is performed under the approxmation valid at low temperatures. Thereofre non-negligile number of compounds exhibit imaginary modes that may be removed at elevated temperatures. To treat high temperature properties, several methods have been developted to obtain anharmonic force constants by large atomic displacements [8,9]. Our next challenge is high-throughput phonon calculation with anharmonicity for which we still have to develop robust software environment. We review current computing system to perform the high-throughtput harmonic phonon calculation and discuss what kinds of software packages will have to be developed for high-throughtput anharmonic phonon calculations.

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