A new calculation method of normal mode eigenvalue problem

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Recently some phenomena which show oscillations of the solid earth with atmospheric oscillations have been reported. On the Pinatsubo eruption in 1991, monotonic surface waves were excited by the explosive eruption. They are interpreted as surface waves and sound waves excited in the atmosphere. In our analyses of continuously excited free oscillations, 0S29 which are located at the branch crossing between Rayleigh waves and atmospheric sound waves has excess amplitude and it can be interpreted by contribution of the sound waves. Sound waves excited by earthquakes and Rayleigh waves propagating in the ionosphere are also often reported.

In this way, there are many cases that we cannot ignore the atmosphere to describe oscillation phenomena. However the atmosphere is not rigid barrier for propagating waves. This means that even solid modes essentially have energy leakage and they are dissipative. So eigenvalues of normal modes become complex values. A search for complex eigenvalues is generally more difficult numerical task. An efficient method is desirable in this situation. Here we propose an efficient method of normal mode calculations.

On earth's normal mode calculations, shooting methods are usually used. In the methods, roots of a characteristic function are iteratively searched, which becomes hard work if the roots become complex values. On the other hand, a relaxation method are used in calculations of solar oscillations. It is much effective if initial eigenvalue and eigenfunction are near the true solution and the effectiveness are not dependent on the problem to be solved is real or complex. Our method has merits of both methods. It don't need initial eigenfrequencies and eigenfunctions as the shooting methods and it can automatically find eigenvalues and eigenfunctions in the sense of the relaxation methods. The method is also numerically stable. In fact, we can calculate eigenfunction of waves those energies are concentrated near the surface of the earth such as ocean waves from a vicinity of the center of the earth.

In this talk, we explain the proposing method and show some calculation results of the coupled mode 0S29 with atmospheric waves and normal modes of the moon up to 0.5 seconds.