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Rayleigh波频散曲线“交叉”及多模式耦合作用研究

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摘要 Rayleigh波可以用来反演近地表结构，在工程物探、石油物探、地球内部结构探测中均有重要意义.数值计算得到的含低速层的层状介质对应的Rayleigh波频散曲线会出现看似“交叉”的现象，但是对于这种现象目前还没有进行系统的研究.事实上可以验证，有些看似交叉的频散曲线实际上不相交.改变低速层的厚度和横波速度发现低速层越明显（即低速层速度越低或层厚越厚）频散曲线越不容易相交.凡友华等在2007年提出频散曲线对应着四种基本模式，在频散曲线发生“交叉”现象的区域实际上存在两个以上模式的频散曲线.本文主要研究了存在R模和S_2模的区域内频散曲线的“交叉”现象.首先利用竖直本征振动曲线研究R模和S 2模Rayleigh 波的振动特点，发现R模对应的本征振动主要集中在地表，随着深度变化能量快速衰减，S_2模对应的本征振动主要集中在第2层.研究“交叉点”附近频散点对应的本征振动曲线发现这一区域有些Rayleigh波同时具有R模和S_2模的振动特点，对应着一种耦合模式.通过对实例的研究发现，在“交叉点”附近，若两条频散曲线不发生交叉，则每条曲线对应的模式会发生R模和S_2模之间经由耦合模式的转变，本文称这种现象为两种模式发生耦合；若两条频散曲线相交，则同一条频散曲线上的Rayleigh波模式几乎相同，只是在离交点很近的区域会存在一些耦合模式，本文称此时两种模式不发生耦合.本文研究结果主要供Rayleigh波对低速层结构的反演研究参考.

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Research on the cross of the dispersion curves of Rayleigh waves and multi-modes coupling phenomenon

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Abstract Rayleigh wave, which used to be seen as the interferential wave, can be used in the inversion of the structure near the surface. It is also very meaningful in geophysical exploration, oil exploration and so on. There will be some dispersion curves that seem to cross each other for multilayered medium containing a low velocity layer. However, there is no systematic research about the phenomenon. In fact, it can be seen that some seemingly crossing dispersion curves do not actually cross. Changing the thickness and the S-wave velocity of the low velocity layer, we found that the more evident the low velocity is (i.e. the low velocity layer is thicker or has a lower S-wave velocity), the harder the dispersion curves to cross. Fan et al found that there are four basic modes of Rayleigh wave dispersion curves, so there are two different modes in the area that dispersion curves seem to cross. In this paper, the ‘cross’ phenomenon in the area that has both R mode and S_2 mode is analyzed. First, with vertical eigen displacement curves, it can be found that the energy of vibration of R mode wave is mainly near the surface of the medium and decreases quickly with depth, forms surface wave while the energy of vibration of S_2 mode waves is mainly in the second layer, forms guide wave. Eigen displacement curves show that some Rayleigh waves near the ‘cross point’ have both the characters of R mode and S 2 mode, so that is a kind of coupled mode. From the research of given model, we found that in the area near the ‘cross point’, if the two dispersion curves do not cross, transformation between R mode and S_2 mode via coupled mode happens to the mode on each curve, we call the phenomenon ‘coupling phenomenon’ of Rayleigh wave mode in this paper. If the two dispersion curves cross, the mode corresponding to the same dispersion curve is almost the same, though there is some coupled mode very close to the cross point, we say the modes do not couple. The content of this paper can be used as a reference in the inversion of the structure with low velocity layer.

Key words Rayleigh wave; Dispersion; Multilayered media; Multimode

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