Global Seismology 2 (GEO-1509)

Tentamen - 27 January 2005

Jeannot Trampert

The numbers in () indicate the percentage for evaluation. No documents are allowed during the examination. Please write clearly and don't forget to indicate your name.

1. (30) For Love waves we can define the following energy integrals

$$I_1 = \frac{1}{2}\int_0^\infty \rho l_1^2 dz$$
$$I_2 = \frac{1}{2}\int_0^\infty \mu l_1^2 dz$$
$$I_3 = \frac{1}{2}\int_0^\infty \mu (dl_1/dz)^2 dz$$

Explain what all the variables in the integrals mean. Using the above definitions we can derive the useful relations

$$\omega^2 \delta I_1 - k^2 \delta I_2 - \delta I_3 = 0$$
$$\omega^2 I_1 - k^2 I_2 - I_3 = 0$$

This allows us to calculate the changes in phase velocity due to changes in rigidity and density as follows:

$$\delta c/c = \frac{\int_0^\infty [k^2 l_1^2 + (dl_1/dz)^2]\delta\mu dz - \int_0^\infty \omega^2 l_1^2 \delta\rho dz}{2k^2 \int_0^\infty \mu l_1^2 dz} \qquad (1)$$

Using the expression $U = \frac{I_2}{cI_1}$ together with (1) calculate the changes in $\delta U/U$ for changes in rigidity and density.

2. (20) Using $\omega^2 I_1 - k^2 I_2 - I_3 = 0$ and $U = \frac{I_2}{cI_1}$, show that for a Love wave, the group velocity is always smaller than the phase velocity for a given frequency. (Try to eliminate I_1 between these equations.)

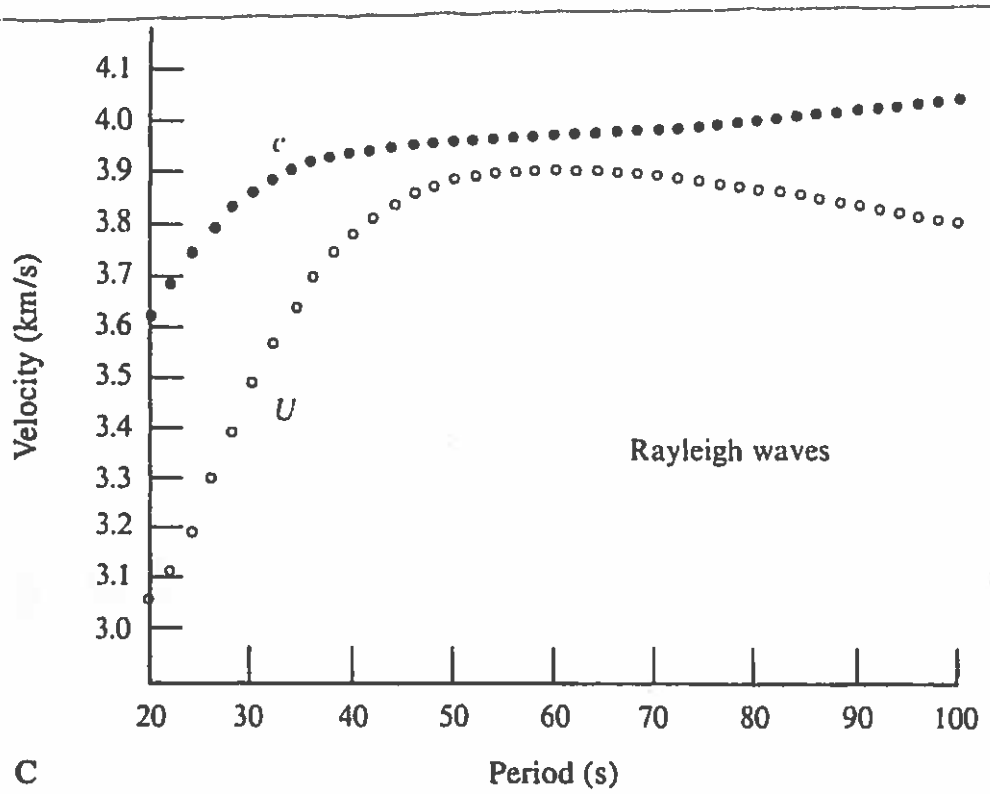
3. (20) The displacement of a Love wave can be written as

$$u^L = G^L[M_{xx}\sin\phi\cos\phi - M_{yx}\cos^2\phi + M_{xy}\sin^2\phi - M_{yy}\sin\phi\cos\phi \qquad (2)$$
$$-\frac{1}{ik_n l_1(h)}\frac{dl_1(h)}{dz}(M_{xz}\sin\phi - M_{yz}\cos\phi)]$$

where G^L is the Green's vector for Love waves, ϕ is the azimuth of the station with respect to the epicentre and h is the depth of the earthquake. u^L is independent of M_{xz} and M_{yz} if the earthquake occurs at the surface. Why? Write in this case the simplified expression for u^L in terms of $\cos 2\phi$ and $\sin 2\phi$. The term in brackets in equation (2) is called the radiation pattern. Draw the radiation pattern for a strike slip oriented East-West, for which $M_{xx} = M_{yy} = 0$ and $M_{xy} = M_{yx} = M_0$

4. (30) Define and explain the difference between group and phase velocity in general. Looking at the attached group and phase velocity for a fundamental mode Rayleigh wave, sketch what a seismogram would look like at a distance of ten thousand km.

Good luck.



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Phase and group velocity of the fundamental-mode Rayleigh waves for the Gutenberg Earth model.