THE RESONANT COUNT DIAGRAM AND SOLAR g MODE OSCILLATIONS

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Dziembowski (1979) has pointed out that the 160-minute solar oscillation may be the result of resonant three-wave interactions. In a resonant three-wave interaction, two oscillation modes couple together, through the nonlinear terms in the pulsation equations, to drive a beat wave, whose frequency equals the frequency difference of the first two waves. If the beat wave has the same frequency as an oscillation mode of the sun (for example, 104 microHz, the frequency of the 160-minute oscillation), then resonance stimulates the amplitude of this mode. Although this can explain how the g mode oscillations enhance their own amplitudes, so that they can be observed on the surface of the sun, it does not appear to be able to explain why only the 160-minute mode is enhanced. We believe that because of the particular frequency separations of the solar g modes, resonant three-wave interactions stimulate only a selected few g modes. The resonant count diagram provides some evidence for this hypothesis.

The resonant count diagram is obtained by plotting the total number of possible resonant three-wave interactions for a given beat frequency (ω_o), against the inverse of the beat frequency (the beat period), within a given frequency tolerance $\Delta\omega$. The abscissa is the beat period and the ordinate is the total number of interactions such that $\omega_1 - \omega_2 = \omega_o \pm \Delta\omega$. If we assume all the resonant interactions contribute equally to the enhancement of a given beat wave, then the peaks in the curve mark the periods of those modes (beat waves) which are most likely to be significantly enhanced.

We have constructed such a diagram using the $l = 1, 2, 3, 4$ g modes calculated by Christensen-Dalsgaard, Gough and Morgan (1979) for a standard model of the sun. The diagram has a significant peak at 160 minutes as well as other peaks at longer periods. When we plotted the g modes that Delache and Scherrer (1983) tentatively identified from the Crimea-Stanford data, we found that these modes corresponded with the other peaks in the diagram. This coincidence between the observed g modes and the peaks in the resonant count diagram leads us to believe that the observed g modes do owe their observability to resonant three-wave interactions.

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If this is the case, the diagram should prove to be a useful diagnostic tool to test the interior mass distribution of solar models. The importance of this diagram can be understood when one considers that the usual method of comparing the theoretical frequency separations of the modes with the observed separations will fail because not all of the modes are enchanced by resonant three-wave interactions. Because the peaks in the diagram correspond to the modes which are most likely to be observed, and because the positions of the peaks depend on the g mode frequency spectrum, which is itself a function of the interior mass distribution of the sun, the diagram can be readily fitted into the observations by adjusting the mass distribution in the solar model. Hence, when a few g modes are positively identified, the diagram should provide a simple method to test our knowledge of the interior physics of the Sun.

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