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On the Relationship between Fourier and Response Spectra: Implications for the Adjustment of Empirical Ground-Motion Prediction Equations (GMPEs)

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Often, scaling of response spectral amplitudes, (e.g., spectral acceleration) obtained from empirical ground motion prediction equations (GMPEs), with respect to commonly used seismological parameters such as magnitude, distance and site condition is assumed/referred to be representing a similar scaling of Fourier spectral amplitudes. For instance, the distance scaling of response spectral amplitudes is related with the geometrical spreading of seismic waves. Such comparison of scaling of response spectral amplitudes with that of corresponding Fourier spectral amplitudes is motivated by that, the functional forms of response spectral GMPEs are often derived using the concepts borrowed from Fourier spectral modeling of ground motion. As these GMPEs are subsequently calibrated with empirical observations, this may not appear to pose any major problems in the prediction of ground motion for a particular earthquake scenario. However, the assumption that the Fourier spectral concepts persist for response spectra can lead to undesirable consequences when it comes to the adjustment of response spectral GMPEs to represent conditions not covered in the original empirical data set. In this context, a couple of important questions arise, e.g., what are the distinctions and/or similarities between Fourier and response spectra of ground-motions? And, if they are different, then what is the mechanism responsible for such differences and how do adjustments that are made to FAS manifest in response spectra? We explore the relationship between the Fourier and response spectrum of ground motion by using random vibration theory (RVT). With a simple Brune (1970, 1971) source model, RVT-generated acceleration spectra for a fixed magnitude and distance scenario are used. The RVT analyses reveal that the scaling of low oscillator-frequency response spectral ordinates can be treated as being equivalent to the scaling of the corresponding Fourier spectral ordinates. However, the high oscillator-frequency response spectral ordinates are controlled by a rather wide-band of Fourier spectral ordinates. In fact, the peak ground acceleration (PGA), counter to the popular perception that it is a reflection of the high-frequency characteristics of ground motion, is controlled by the entire Fourier spectrum of ground-motion. Finally, it is demonstrated, how an adjustment made in Fourier spectral amplitudes is different or similar to the same adjustment made in the response spectral amplitudes. For this purpose, two cases: adjustments to the stress parameter ($\Delta\sigma$) (source term) and to attributes reflecting site response (Vs-κ_0) are considered.