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The active ear: A ring of fire

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The vertebrate ear both responds to and emits sound. Sounds from the ear, known as otoacoustic emissions (OAEs), provide a means to probe the biophysics of auditory transduction and amplification. Spontaneous emissions (SOAEs) can also be present, appearing as coherent peaks in the spectral domain. Statistical properties of SOAEs, such as the "ring of fire"(observed via a 2-D histogram of the analytic signal of a filtered peak), provide compelling evidence for an "active" ear. Yet the underlying mechanisms are still not well understood. The present study focuses on the lizard ear, a relatively simple case that exhibits robust SOAE. The approach is two-fold. First, we develop a theoretical description that combines active nonlinear oscillators with both local and global coupling. This framework is explored computationally and solved in the time domain. Second, we report recent measurements from lizards that characterize the dynamics of SOAE activity in response to transient external stimuli (e.g., chirps and tone bursts), primarily a depression effect where SOAEs are reduced towards the noise floor. While the model captures some features of the data (e.g., the generation of distinct SOAE spectral peaks) but not others (e.g., SOAE bandwidths and the dynamic range of their response to stimuli), it provides insight into the depression effect. Specifically, SOAEs appear to undergo some combination of entrainment (i.e., synchronization to the external stimulus), suppression (i.e., pushed out of the limit cycle into a quiescent state), or a decoherence (i.e., loss of a clustered group effect that forms a peak).

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