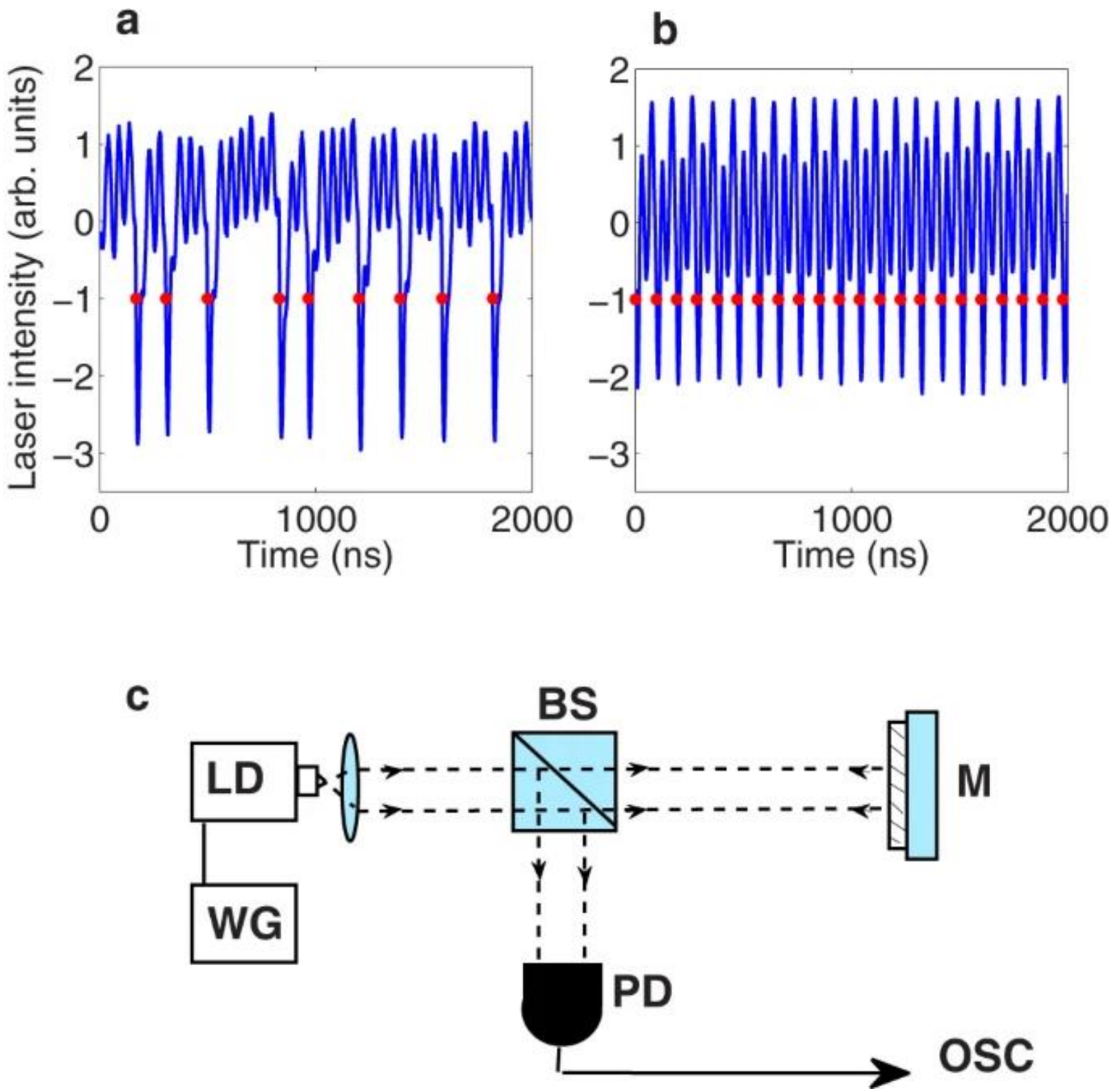
Enhanced study of complex systems by unveiling hidden symmetries with Dynamical Symmetry Visibility

Nhat Nguyen and **Dr. Andrés Aragoneses**

Department of Physics, **Eastern Washington University**, Cheney, WA, 99004, USA.

Photonics & Complexity Lab

Photonic neurons: a diode laser with optical feedback and external modulation



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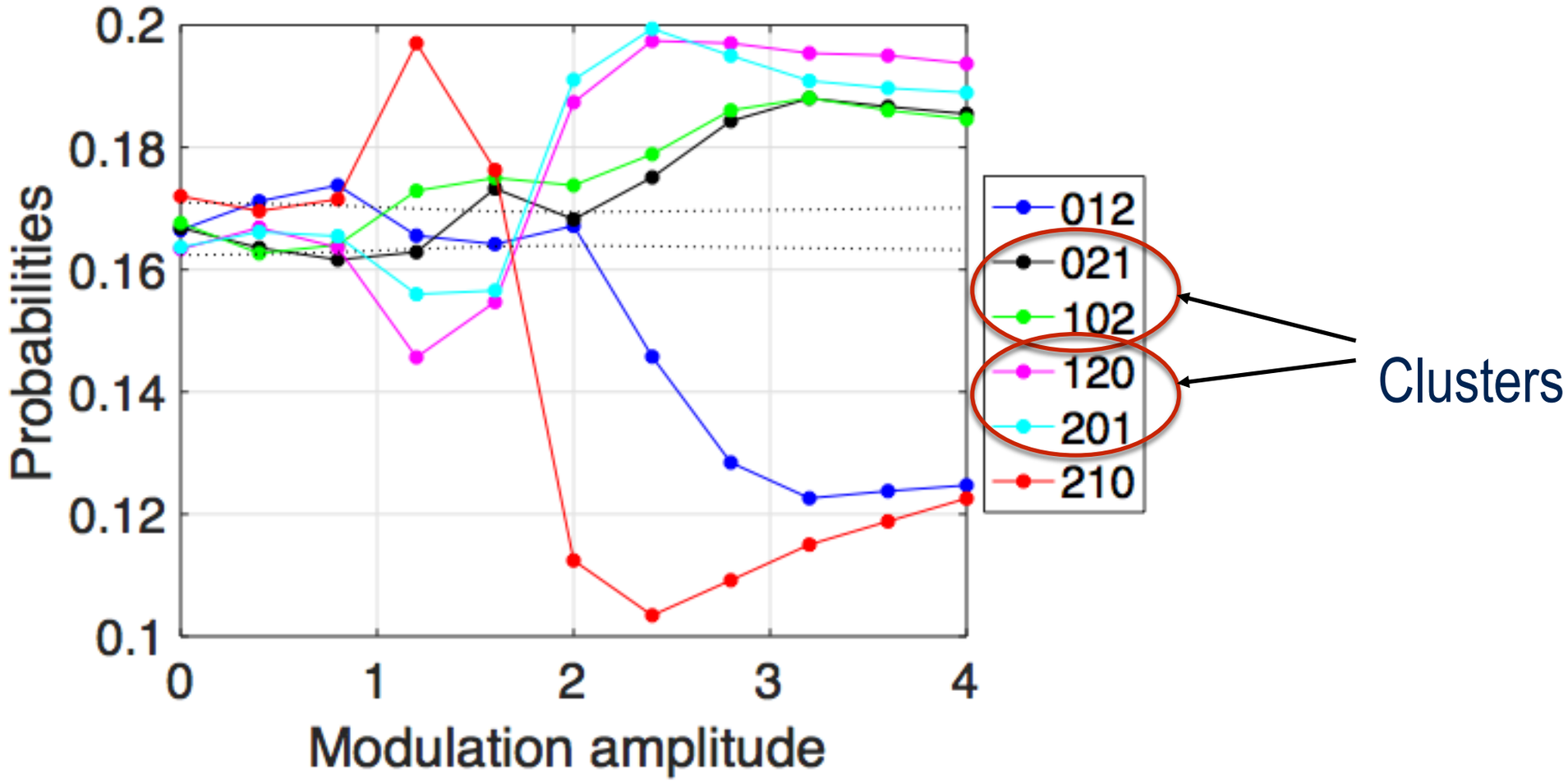


Dynamical Symmetry Visibilities

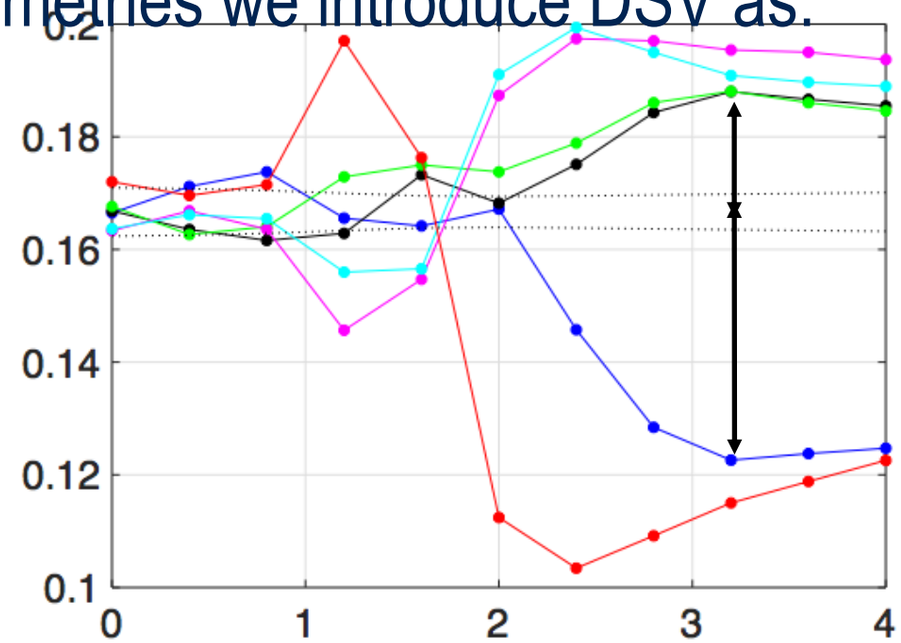
To quantify the presence of temporal, dynamical symmetries we introduce DSV as:

$$V_\alpha = 1 - |w_1 - w_\alpha|$$

$$V_\beta = 1 - |w_6 - w_\beta|$$

$$V_\delta = 1 - |P_2 - P_3| - |P_4 - P_5|$$

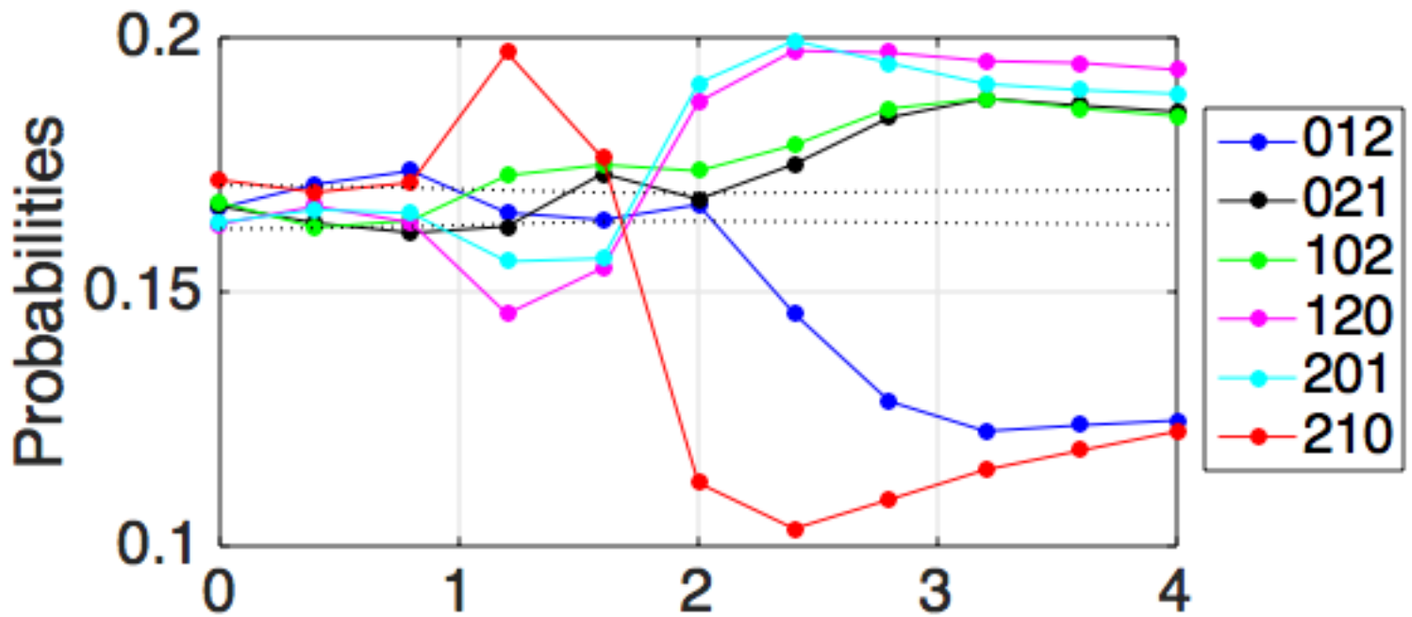
$$V_\rho = 1 - |P_1 - P_6| - |P_2 - P_4| - |P_3 - P_5|$$

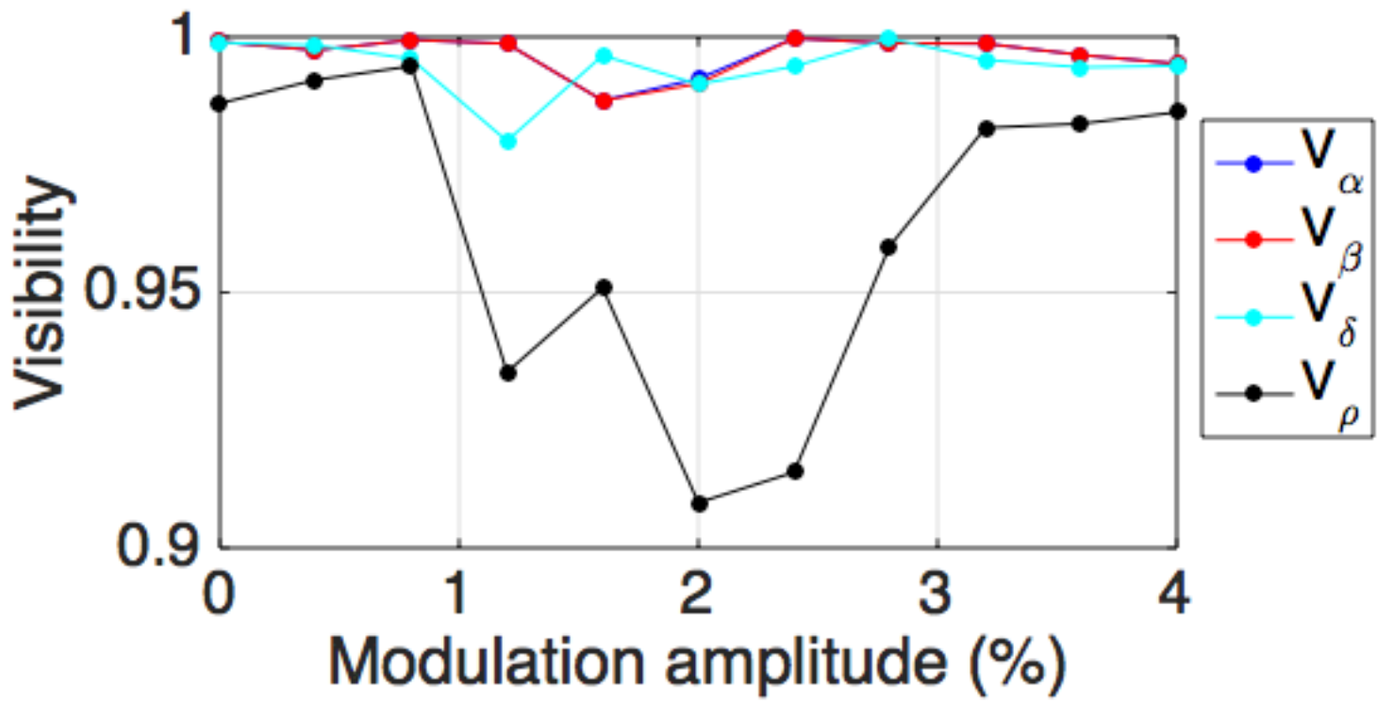


$$w_1 = |P_1 - \frac{1}{6}|$$ → How far word 1 is from randomness

$$w_\alpha = |P_2 - \frac{1}{6} + P_3 - \frac{1}{6}|$$

Dynamical Symmetry Visibilities



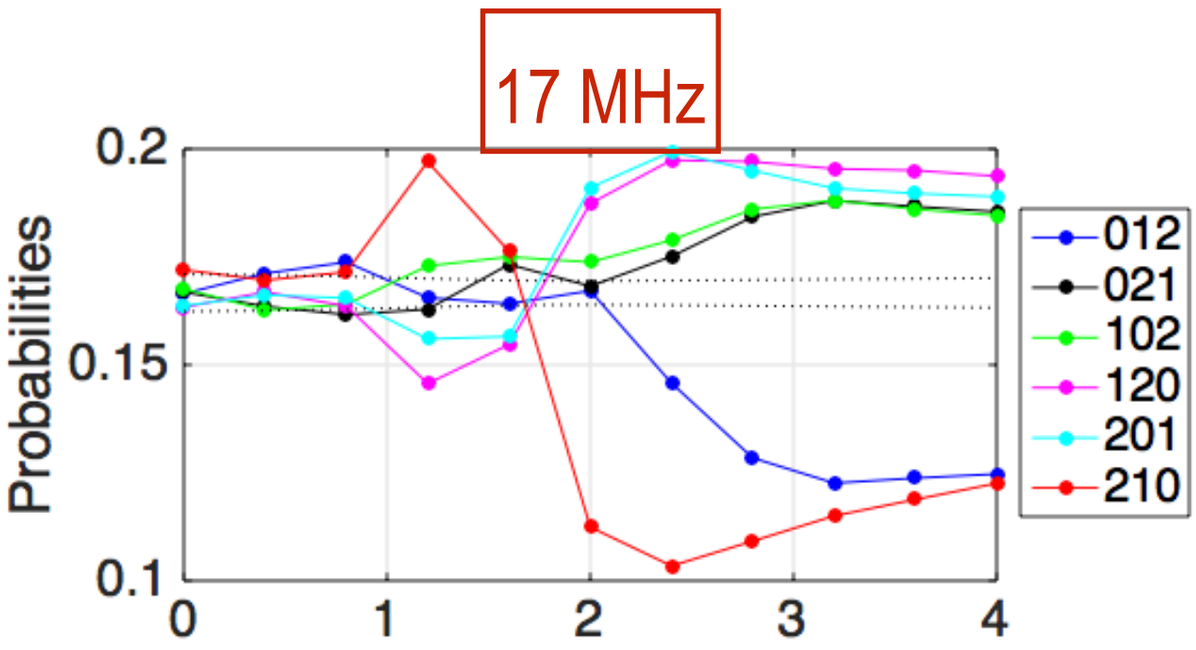


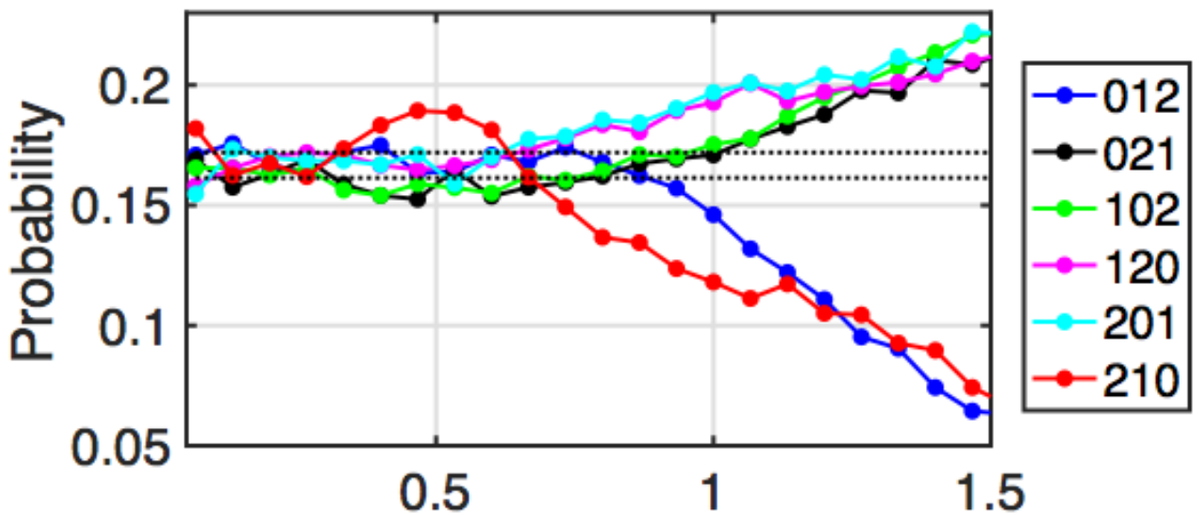
Minimal model to describe photonics neurons

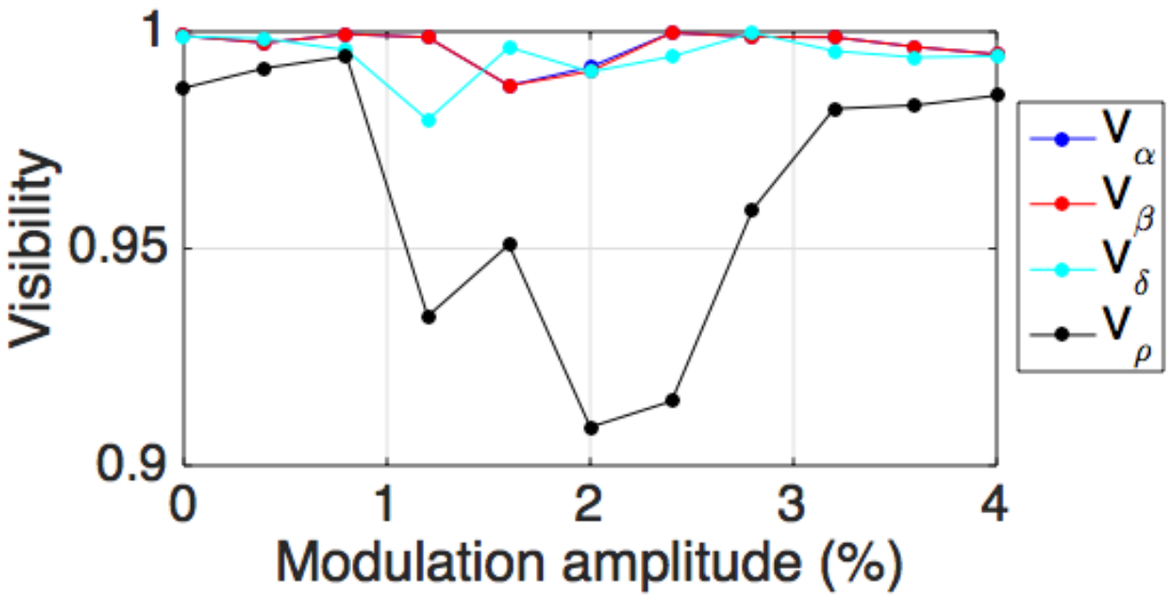
$$\varphi_{i+1} = \varphi_i + \rho + \frac{K}{2\pi}[sin(2\pi\varphi_i) + \alpha sin(4\pi\varphi_i))] + \beta\xi_i$$

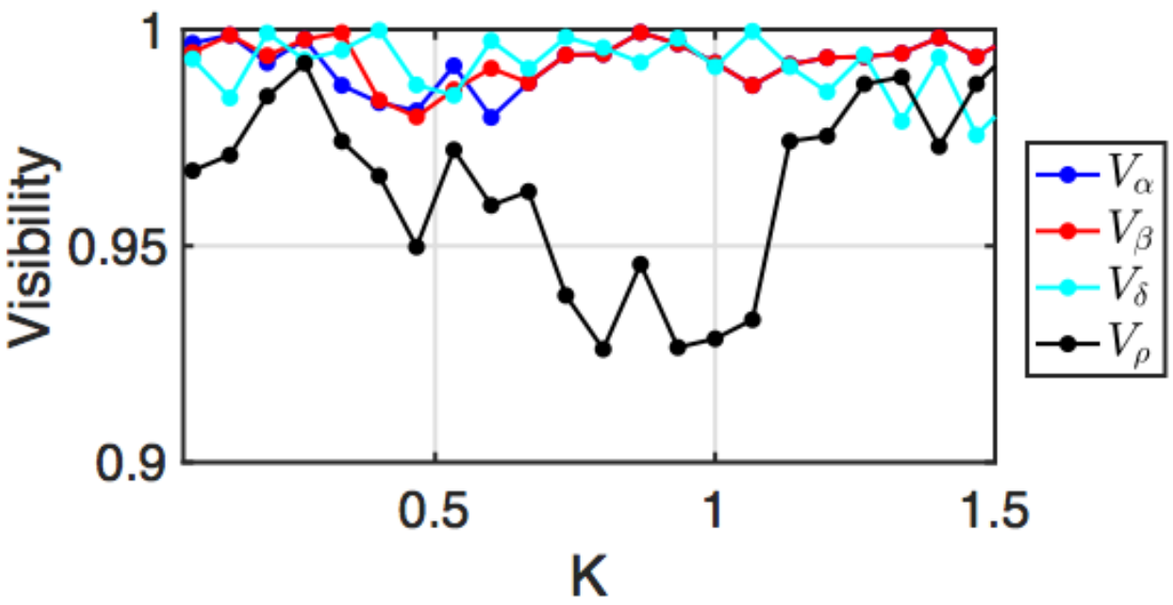
Magnitude of external forcing

Minimal model to describe photonics neurons





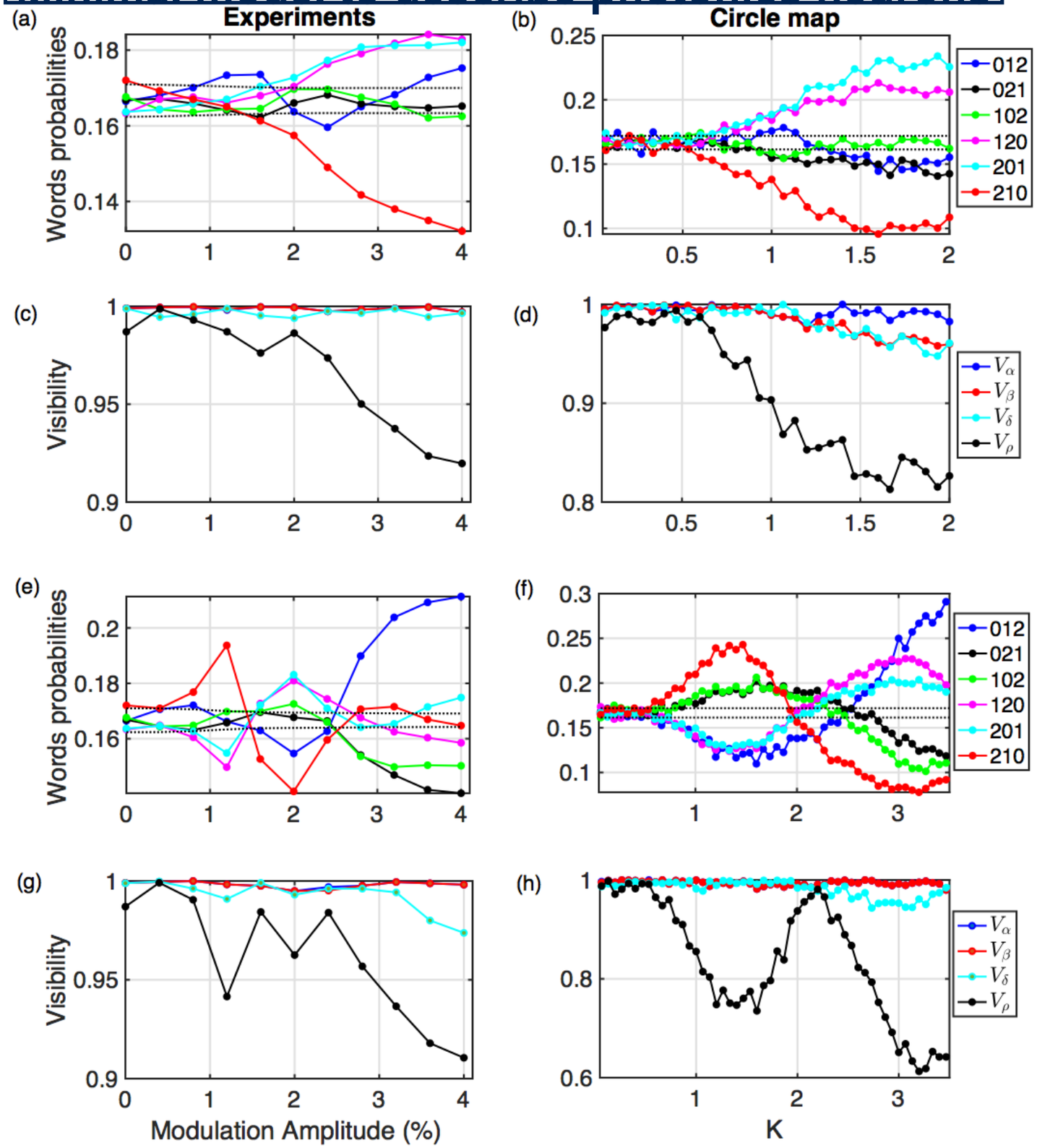




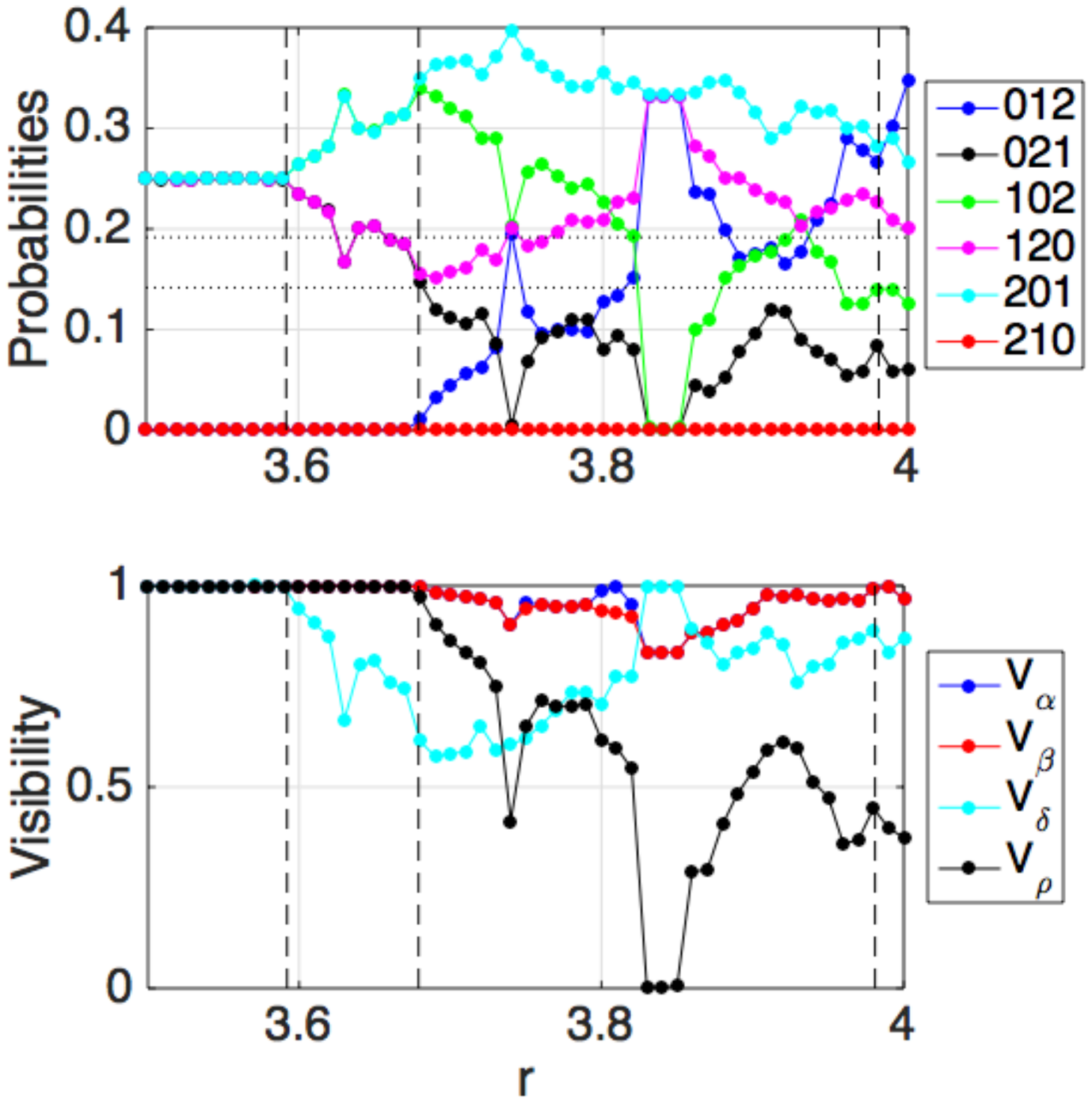
Minimal model to describe photonics neurons

11 MHz

25 MHz



Dynamical Symmetry Visibility & the logistic map



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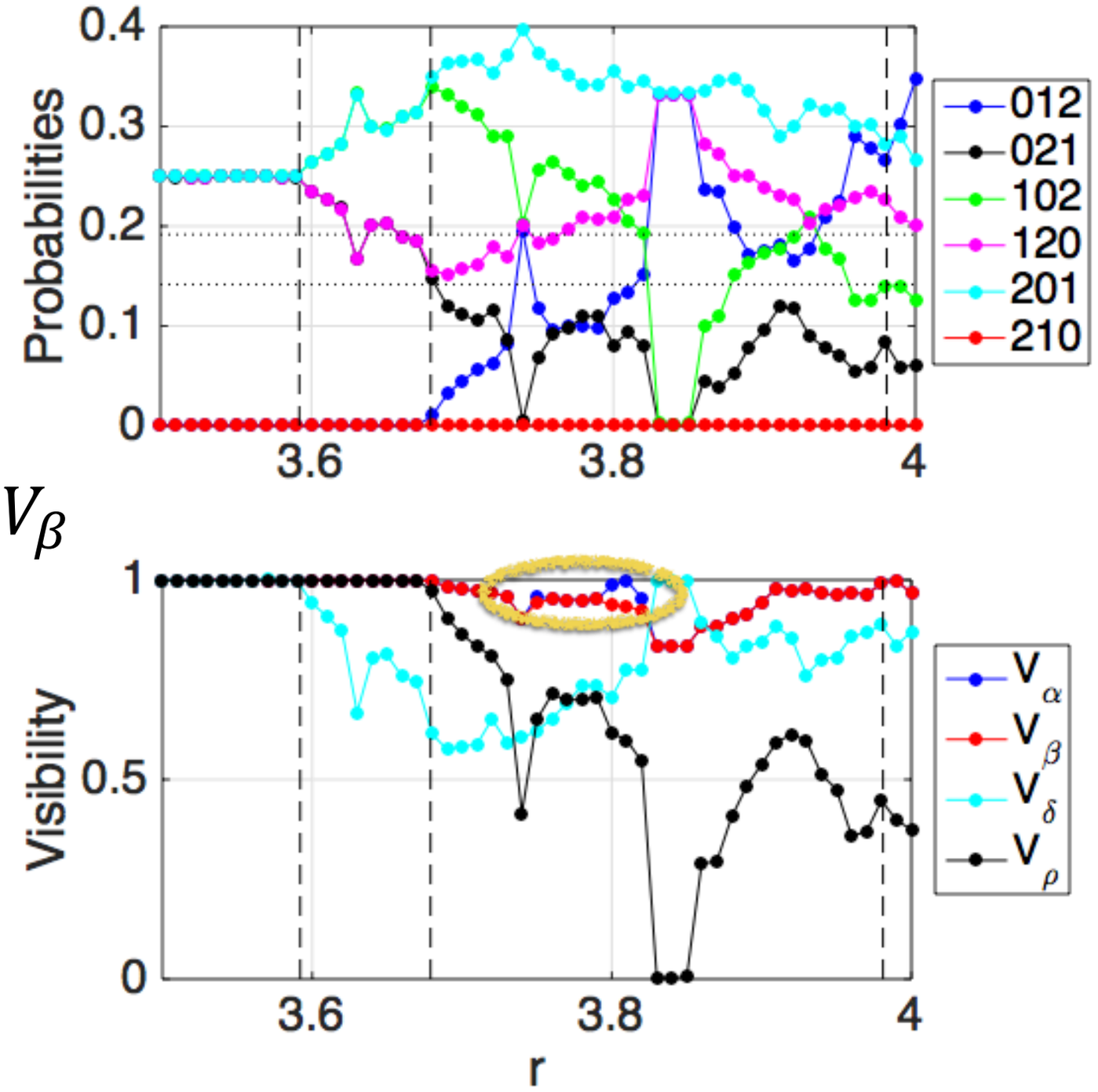
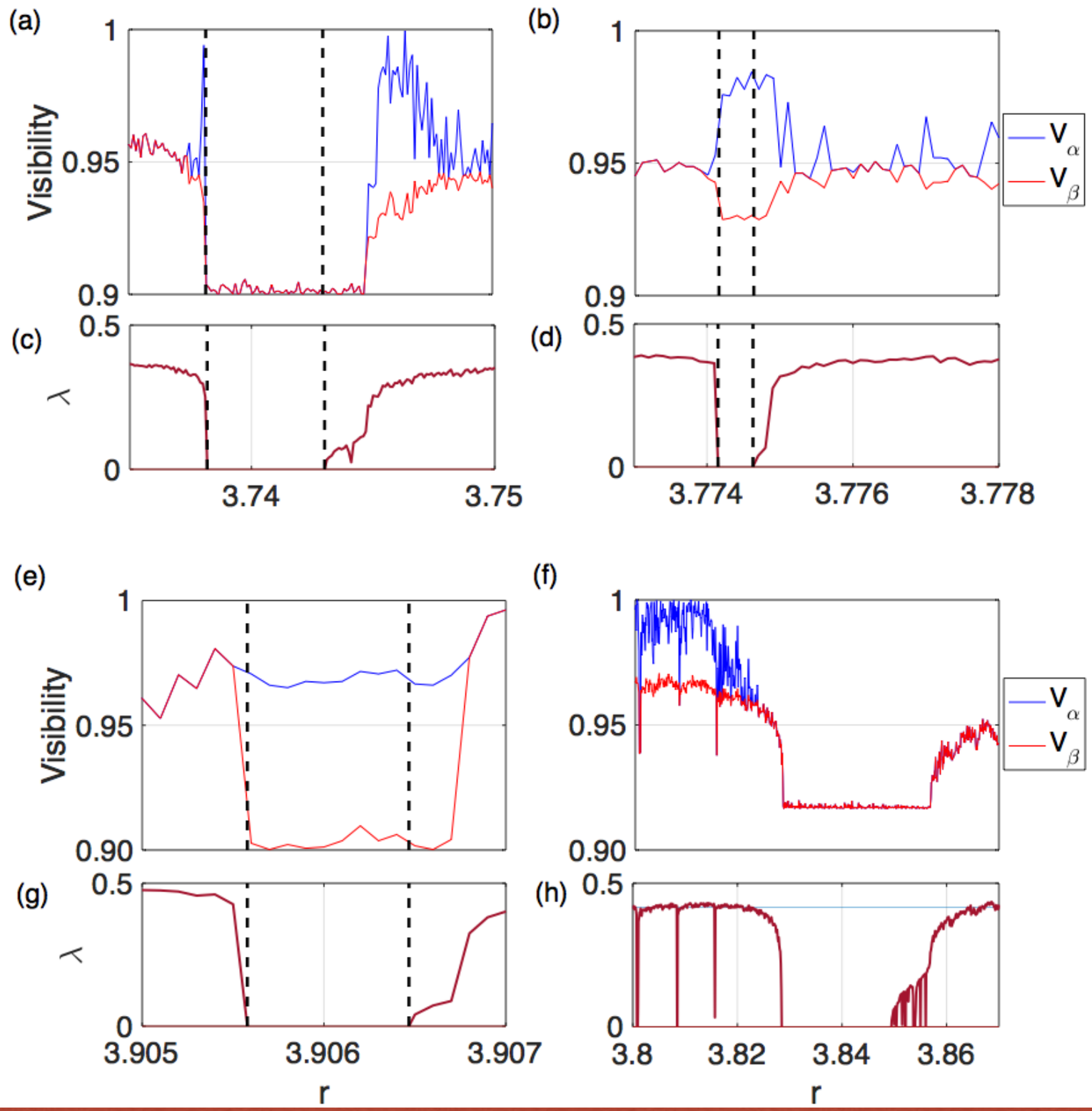
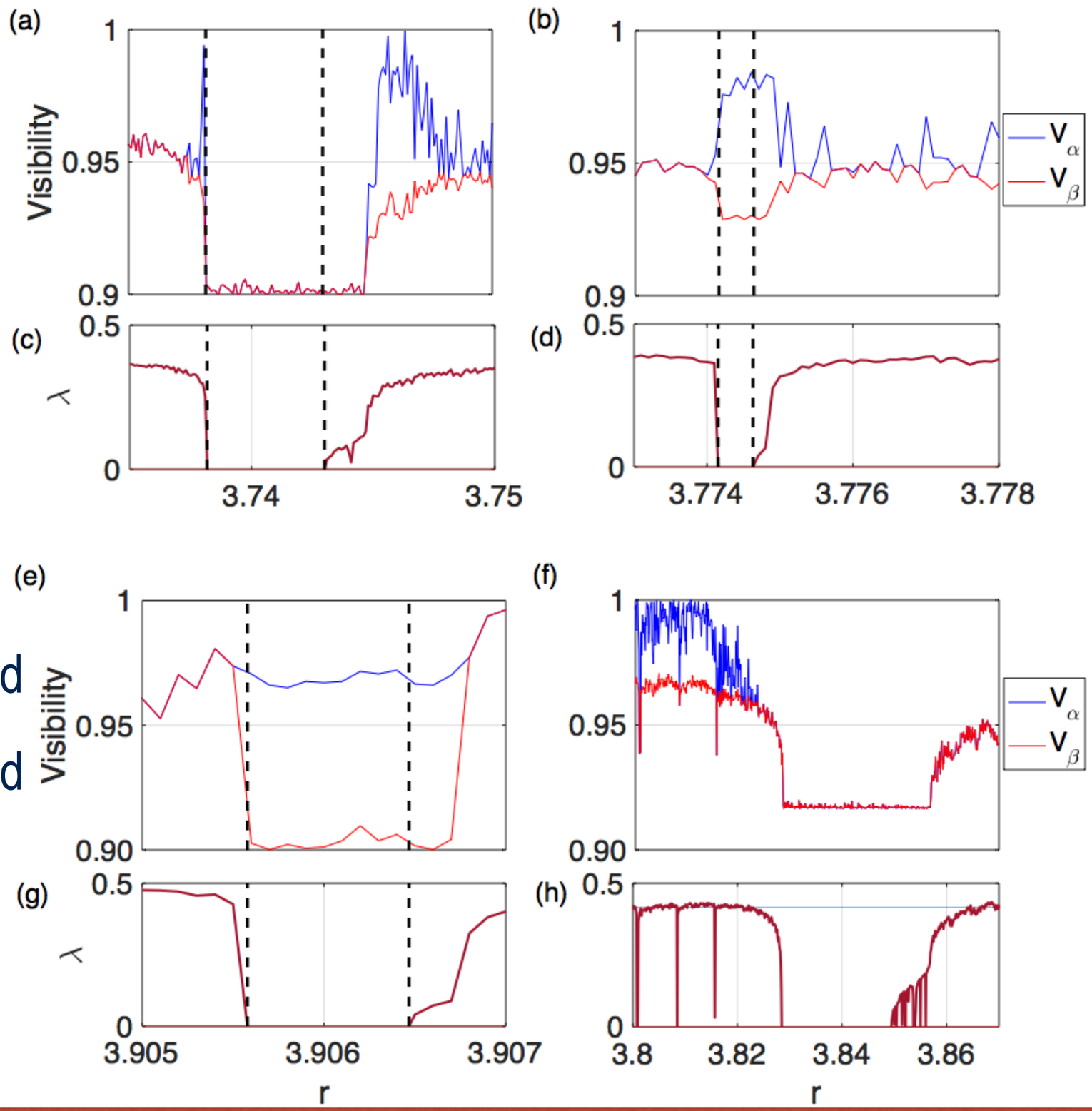


$V_\alpha \neq V_\beta$

Dynamical Symmetry Visibility & the logistic map



Dynamical Symmetry Visibility & the logistic map



Similar results found for sine map, and Ricker's map