# Correlation of Photodetachment Rate and Lyapunov Exponent for a Scarred Resonance State

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# Model & Previous Results

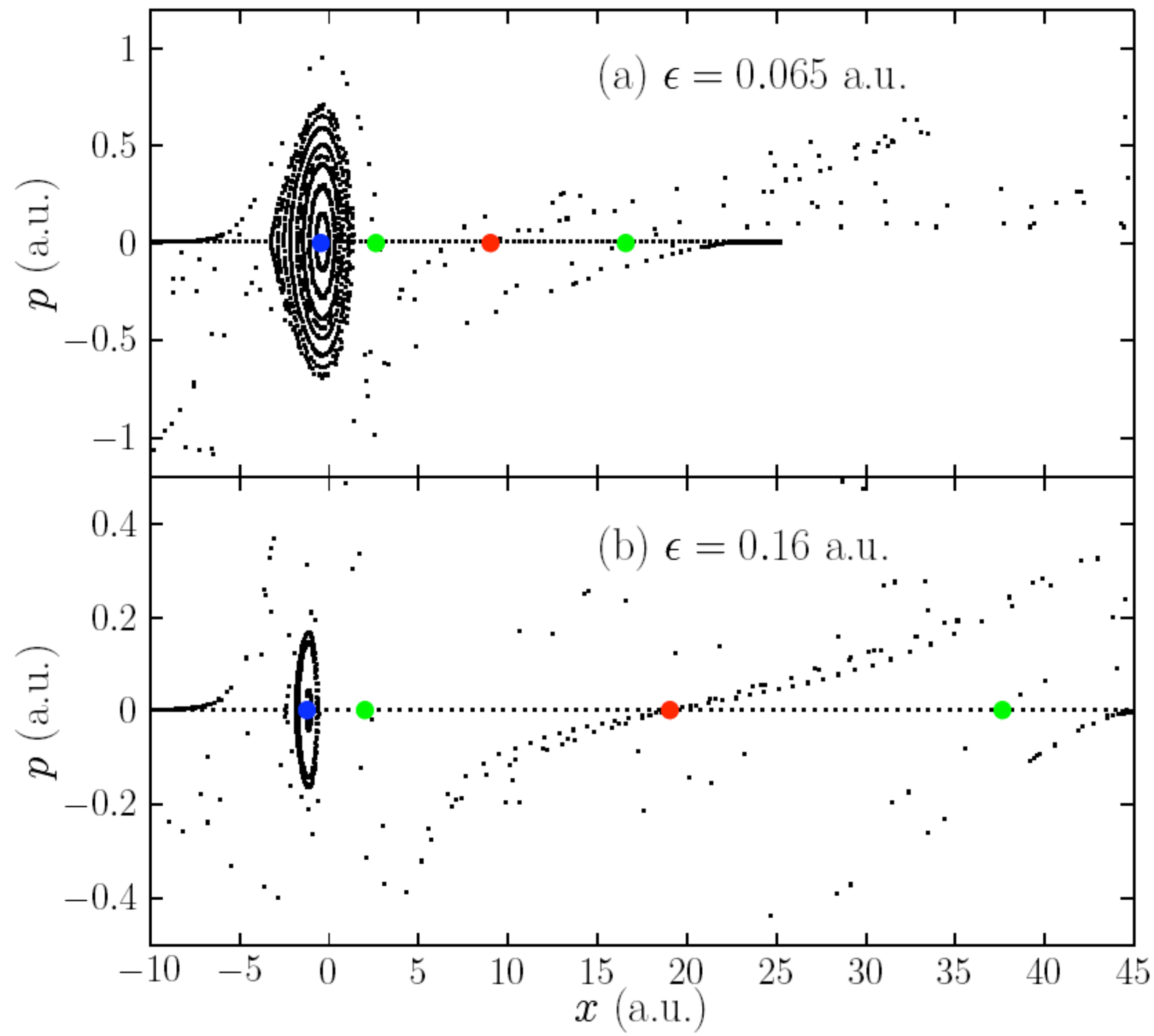
- Driven Inverted Gaussian (rad. gauge, atomic units)

$$H = \frac{1}{2}\left[p - \frac{\varepsilon}{\omega}\sin\omega t\right]^2 - V_0 \exp\left[-(x/a)^2\right]$$

  - $V_0 = 0.63$ a.u., $a = 2.65$ a.u., □ = 0.0925 a.u., □is varied
- Number of quantum resonance states increases as □is increased (Ben-Tal, Moiseyev, and Kosloff, J. Chem. Phys. 98, 9610 (1993)).
- Light-induced resonance states are scarred on unstable periodic orbits of the classical motion (T. Timberlake and L. E. Reichl, Phys. Rev. A 64, 033404 (2001)).
- Possible connection between scarring and stabilization against ionization?

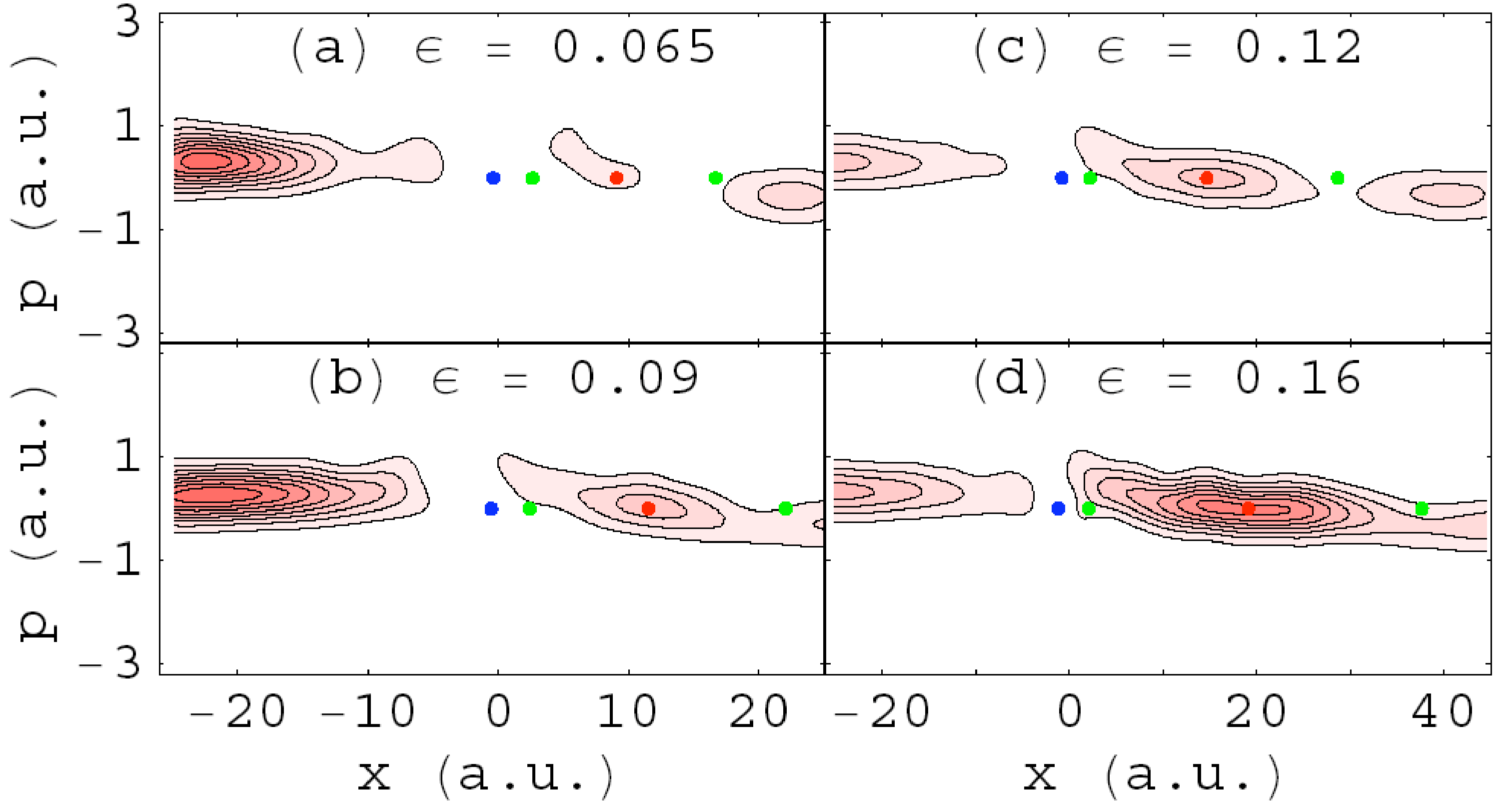
# Classical Dynamics

- Four periodic orbits of period T = 2□/□.
- Orbit A is stable and surrounded by a stable island that decreases in size as □ is increased.
- Orbits B, C, and D are unstable and move apart along p = 0 as □ is increased.



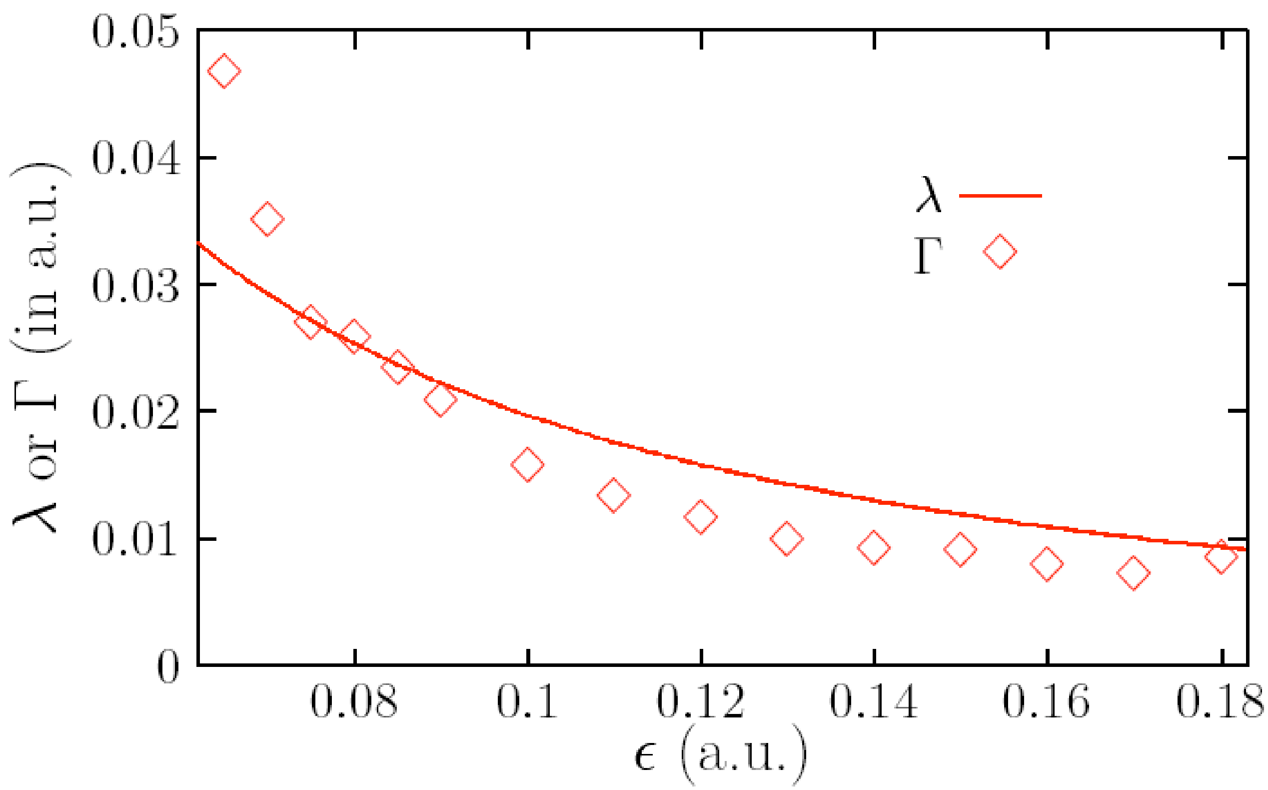
# Scarred Resonance State

- One of the light-induced resonance states that is created as □ is increased has Husimi distributions that are peaked on Orbit C.
- This state is a scar of Orbit C.



# Quantum-Classical Correspondence

- The continuous line shows the Lyapunov exponent (□) of Orbit C.
- The data points show the photodetachment rate (□) of the scarred state. Note that the lifetime is □=1/□.
- Note the similar behavior as a function of □.



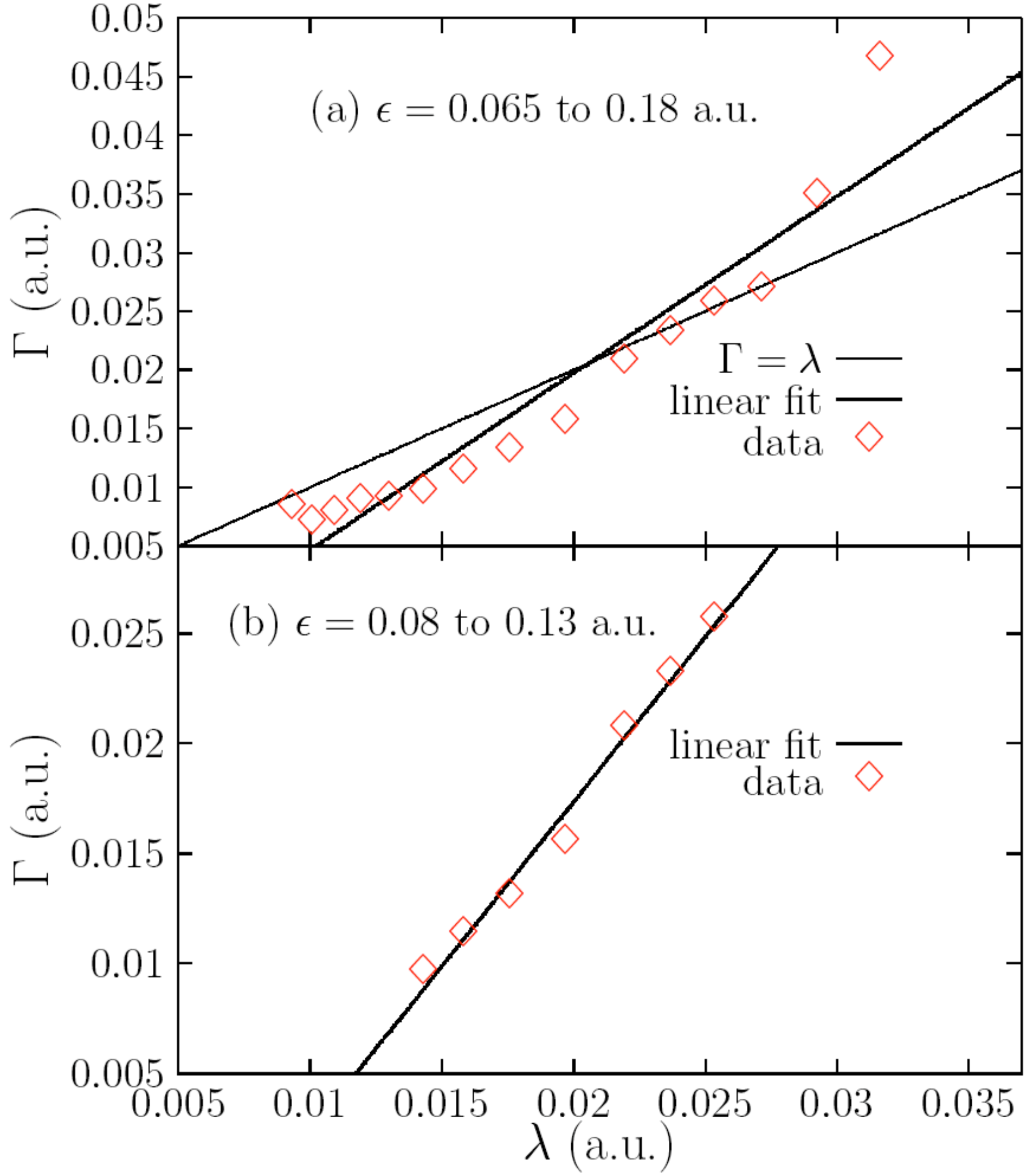
# Correlation of □ and □

- Strong correlation over all field strengths (R = 0.953).
- Best-fit line:

□ = 1.505□ □0.010 a.u.

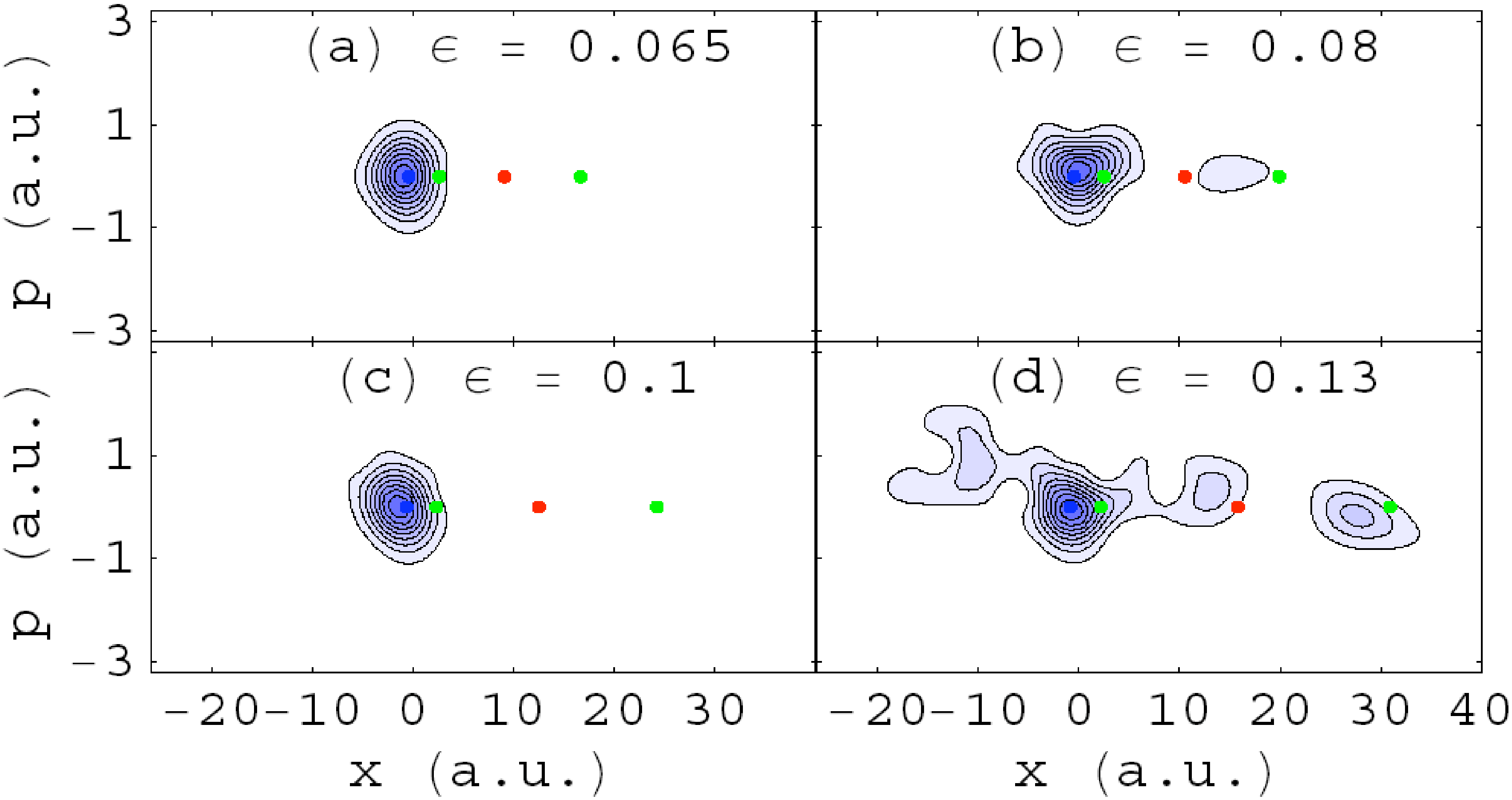
- Very linear in restricted range with R = 0.993.
- Best-fit line:

□ = 1.496□ □0.013 a.u.



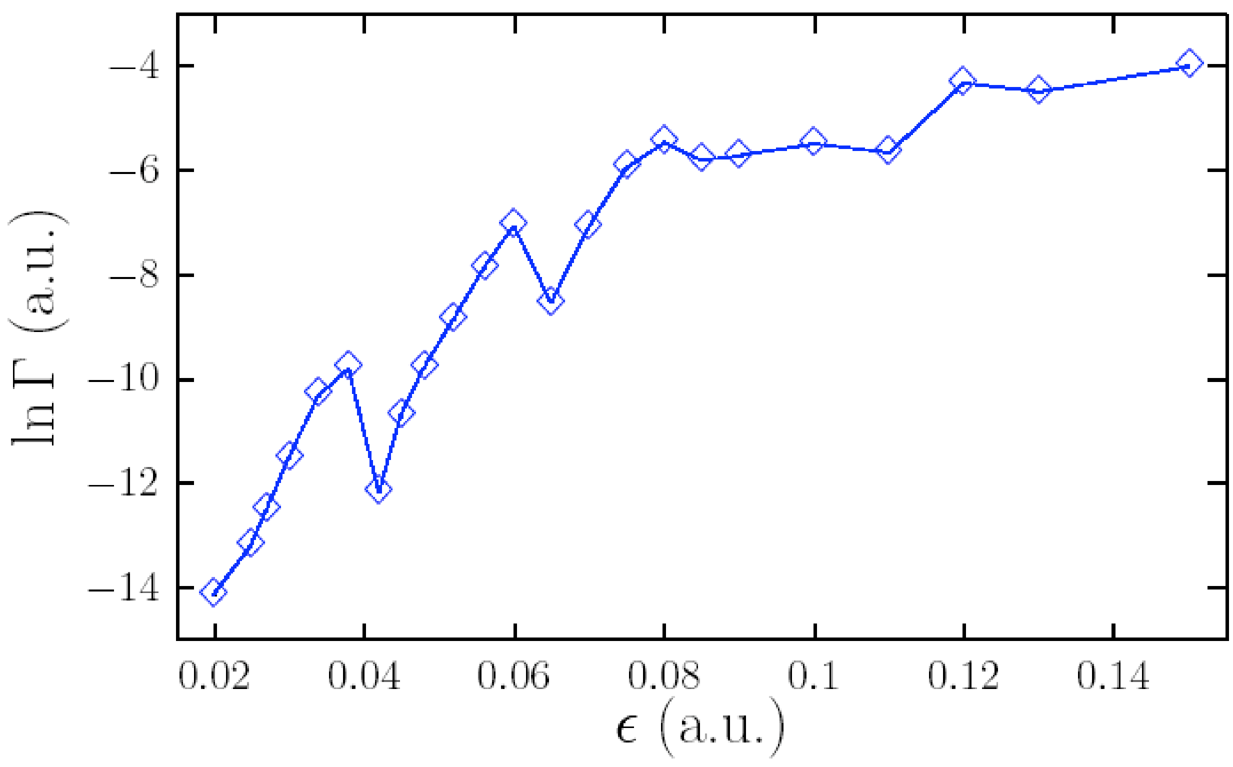
# Stable Island State

- The resonance state that is connected to the ground state as □□ 0 remains peaked inside the stable island until □becomes large.



# □ for Stable Island State

- The photodetachment rate (□) of the stable island state increases as □increases (and the size of the classical stable island decreases).
- The jumps in the plot may be due to avoided crossings in the Floquet spectrum.



# Conclusions

- The lifetime of the stable island state gets shorter and the lifetime of the scarred state gets longer as □ is increased.
- For large □ the scarred state is the longest-lived resonance and its lifetime continues to increase as □ is increased.
- This is evidence for quantum stabilization on an unstable classical structure, but this behavior is still correlated with a classical quantity: the Lyapunov exponent of the unstable orbit.
- The correlation between the photodetachment rate and the Lyapunov exponent represents a new type of quantum-classical correspondence.