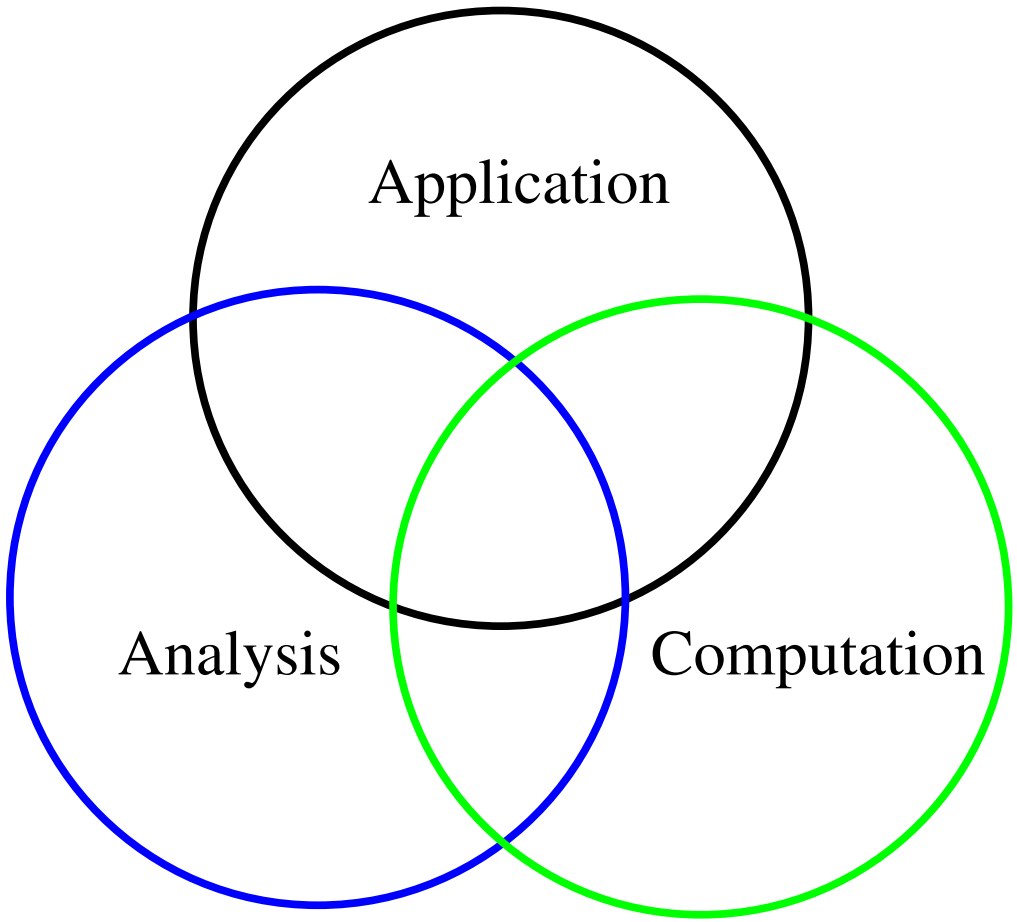
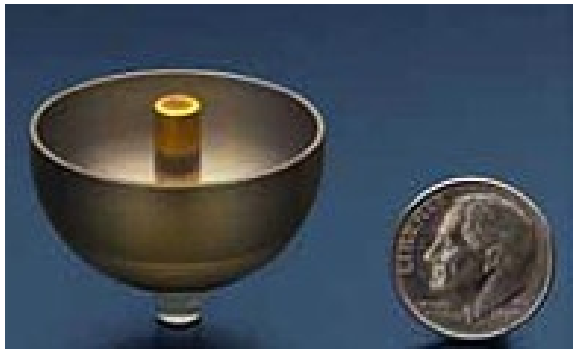
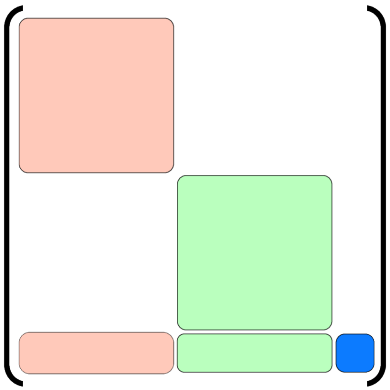
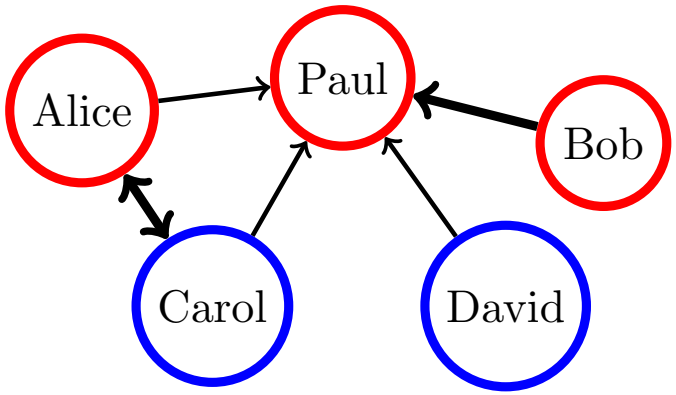
The Computational Science & Engineering Picture

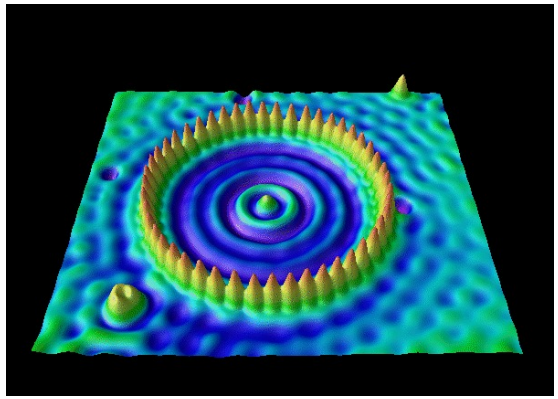


A Few of My Favorite Things

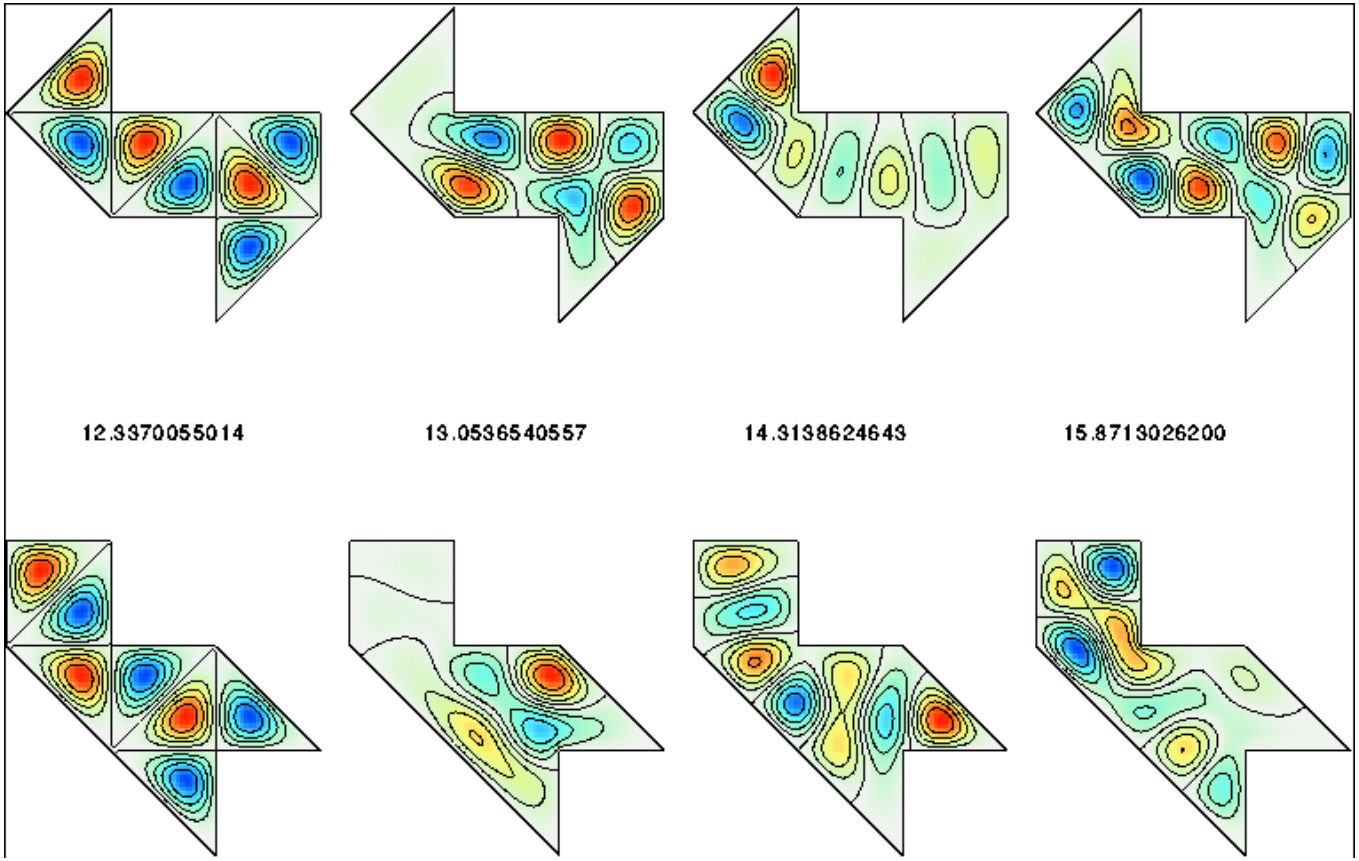






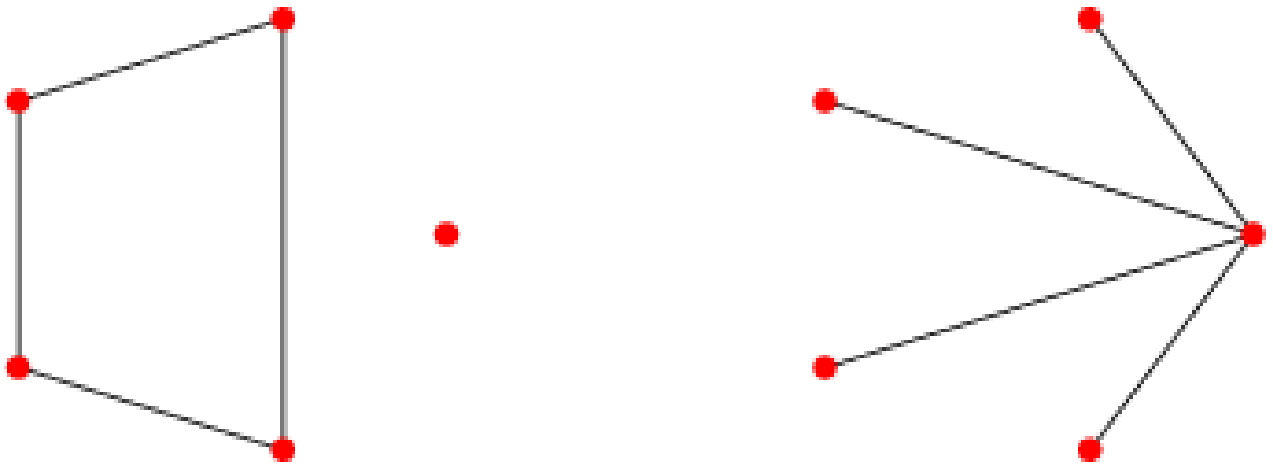


Can One Hear the Shape of a Drum?



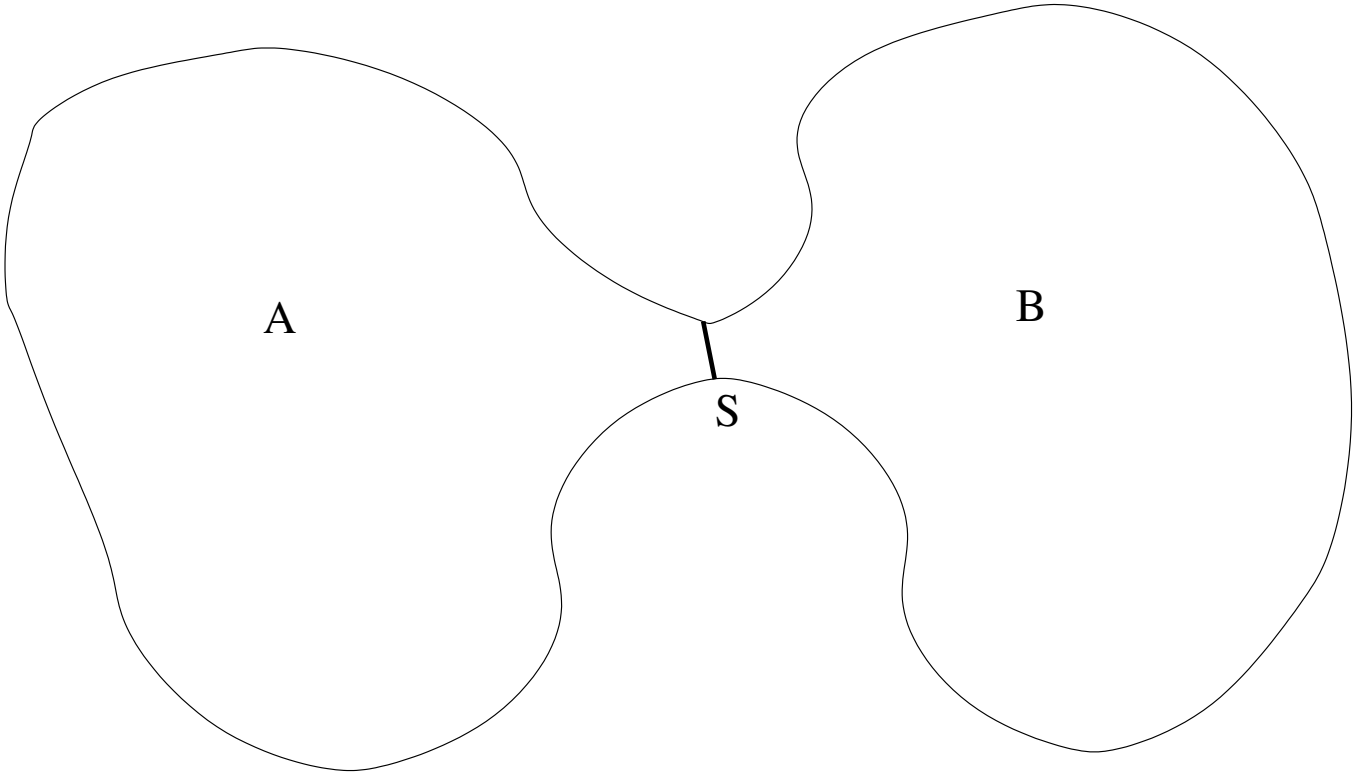
T. Driscoll, computations of Gordon-Webb-Wolpert isospectral example

Can One Hear the Shape of a Graph?



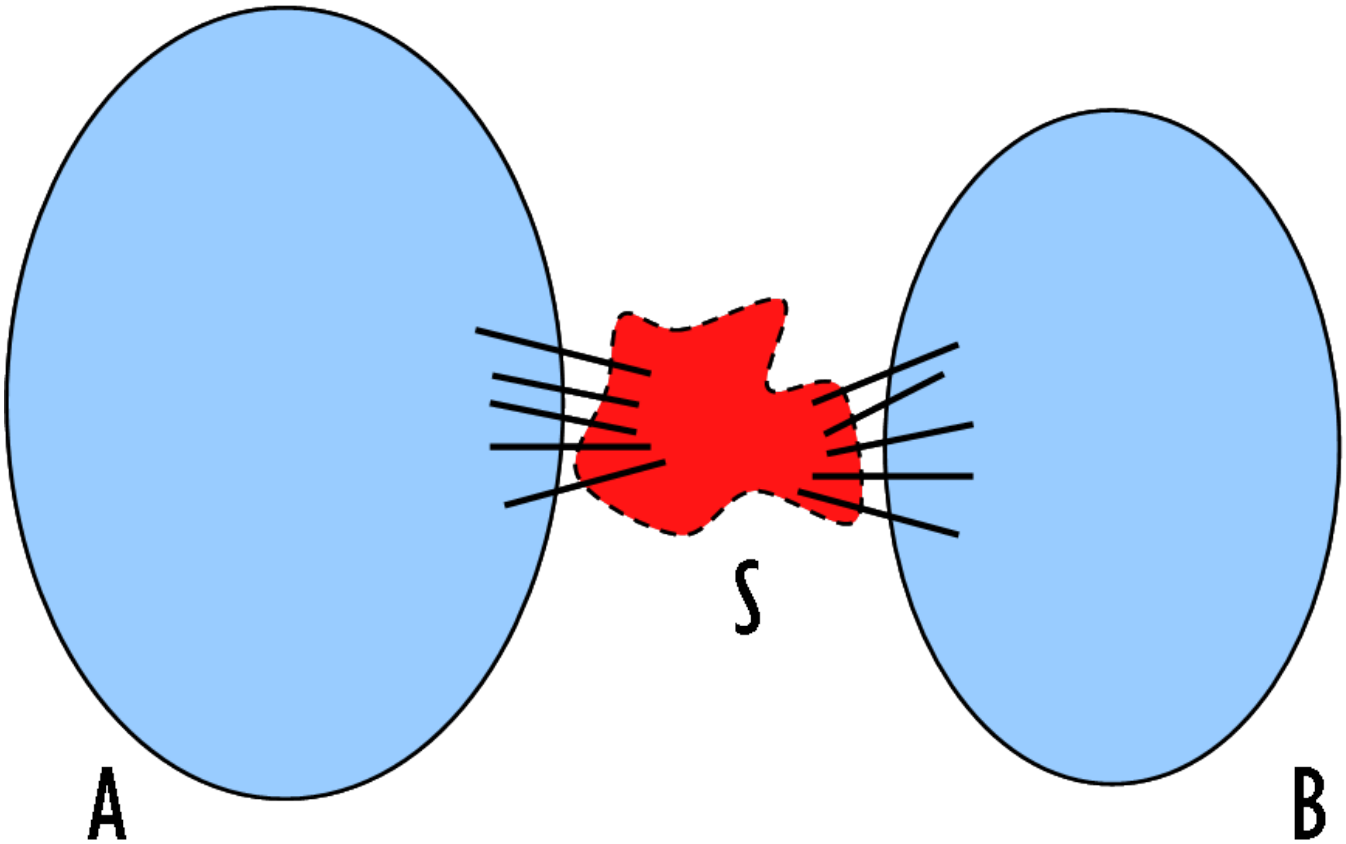
From spectrum of adjacency, Laplacian, normalized Laplacian?

What Do You Hear?



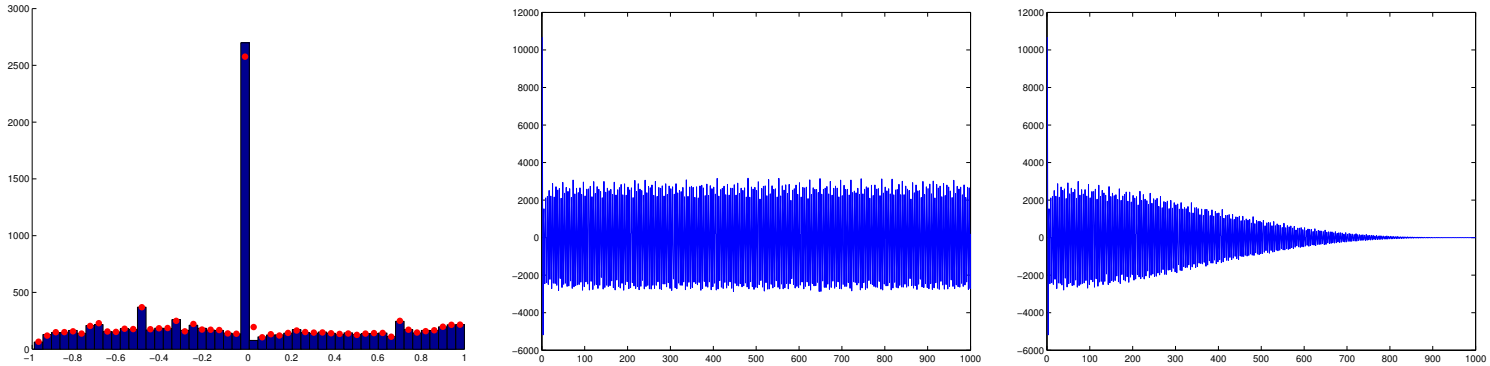
Size of bottlenecks (Cheeger inequality)
Volume (Weyl law)

What Do You Hear?



Size of separators (Cheeger inequality)
What about Weyl?

Fast Spectral Histograms via KPM

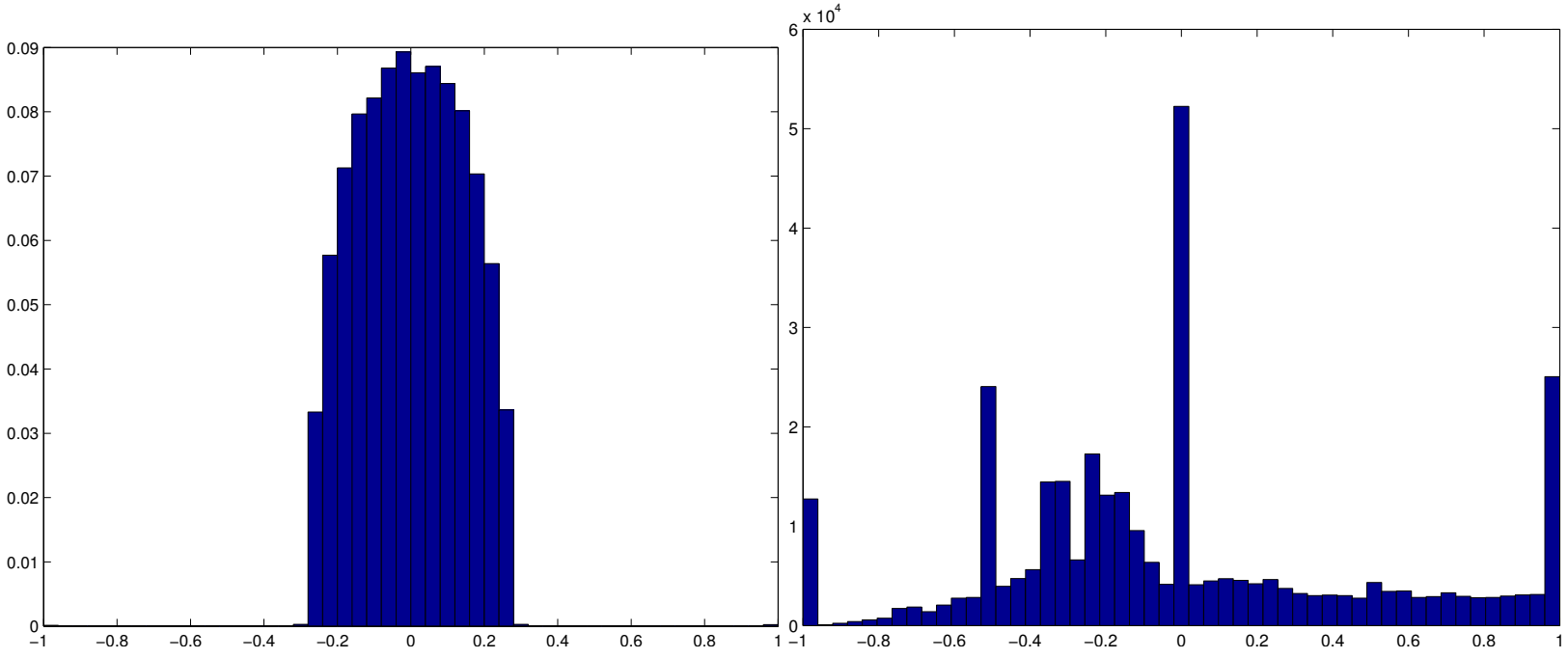


Represent distribution by Chebyshev moments

$$\mu(x) = \frac{1}{n}\sum_{j=1}^{n}\delta(x-\lambda_j) \quad \mapsto \quad c_j = \frac{1}{n}\sum_{j=1}^{n} T_j(\lambda_j)$$

1. Stochastic moment estimator $c_j = E[z^T T_j(A) z]$
2. Filter in Chebyshev space (smooth in real space)
3. Transform back to real space

Random vs Real Graphs



Exploring Spectral Densities

Things we know

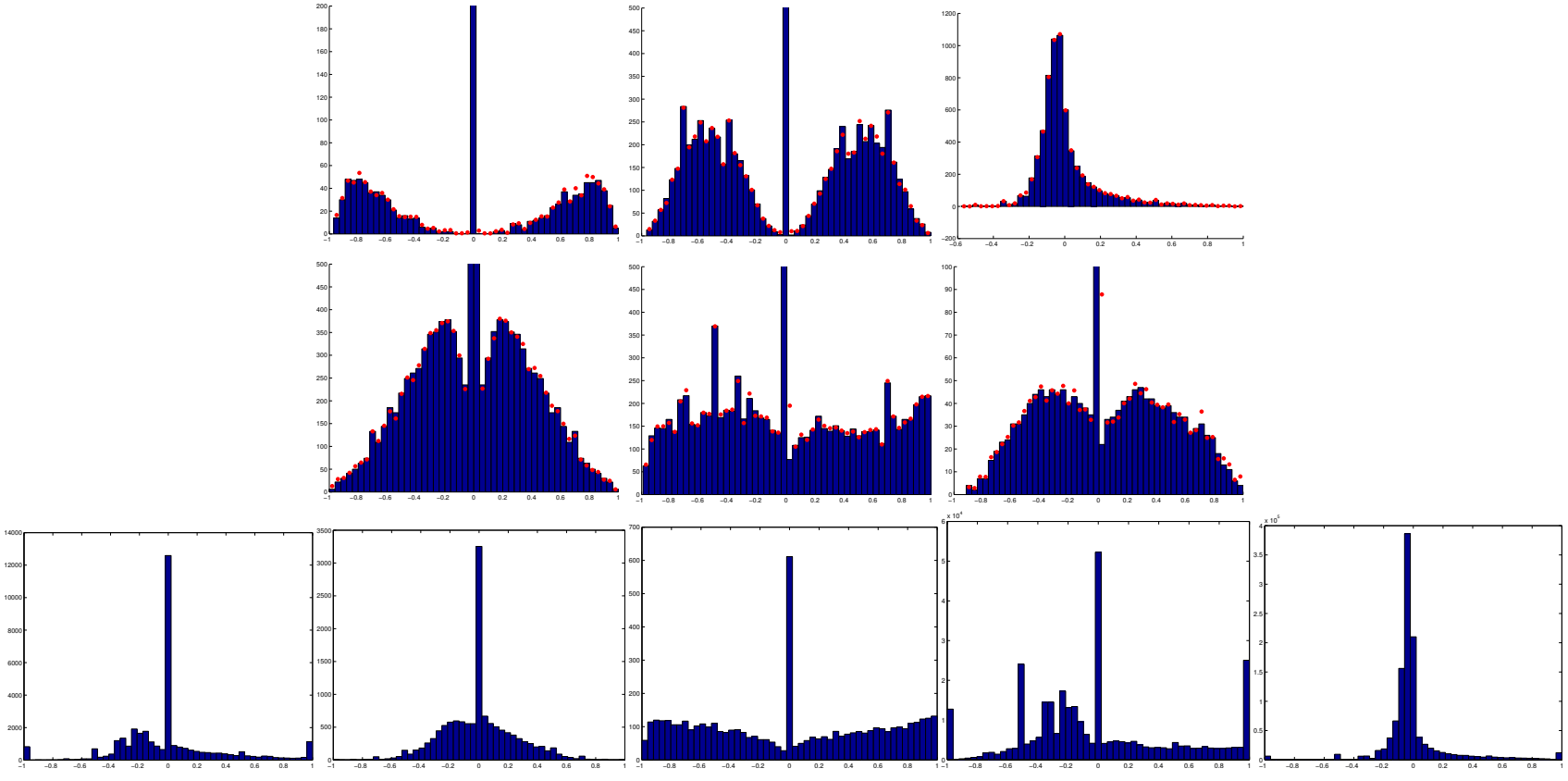
- Eigenvalues in $[-1, 1]$; nonsymmetric in general
- Stability: change d edges, have

$$\lambda_{j-d} \leq \hat{\lambda}_j \leq \lambda_{j+d}$$

- kth moment = probability of return after k-step random walk
- Cluster near 1 $\sim$ well-separated clusters
- Cluster near 0 $\sim$ triangles connected by one node

What else can we “hear”?

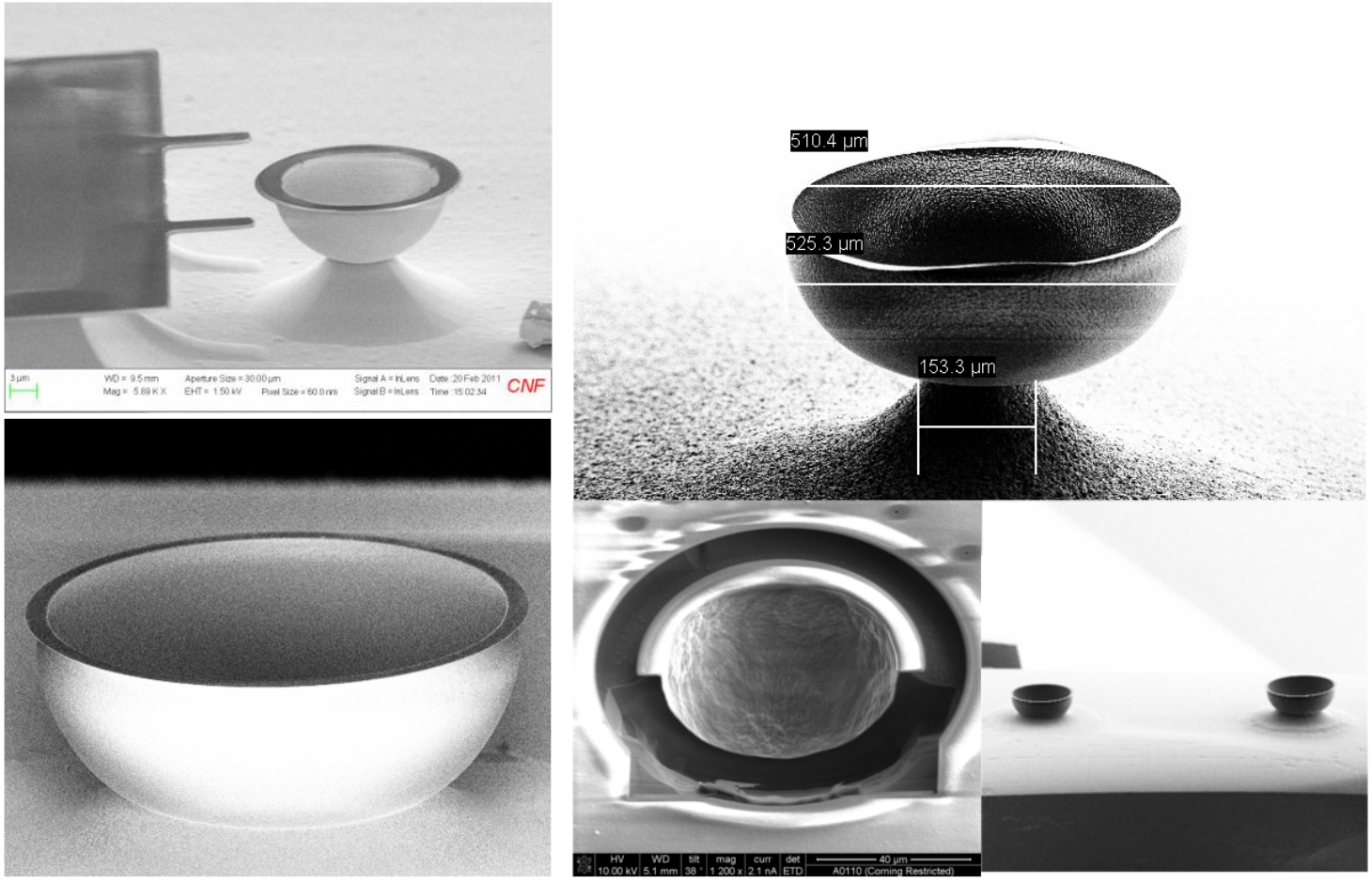
What Do You Hear?



Ad: Declarative HPC and Clouds

(with Gehrke and Demers)

Ad: Simulating Next-Generation Sensors

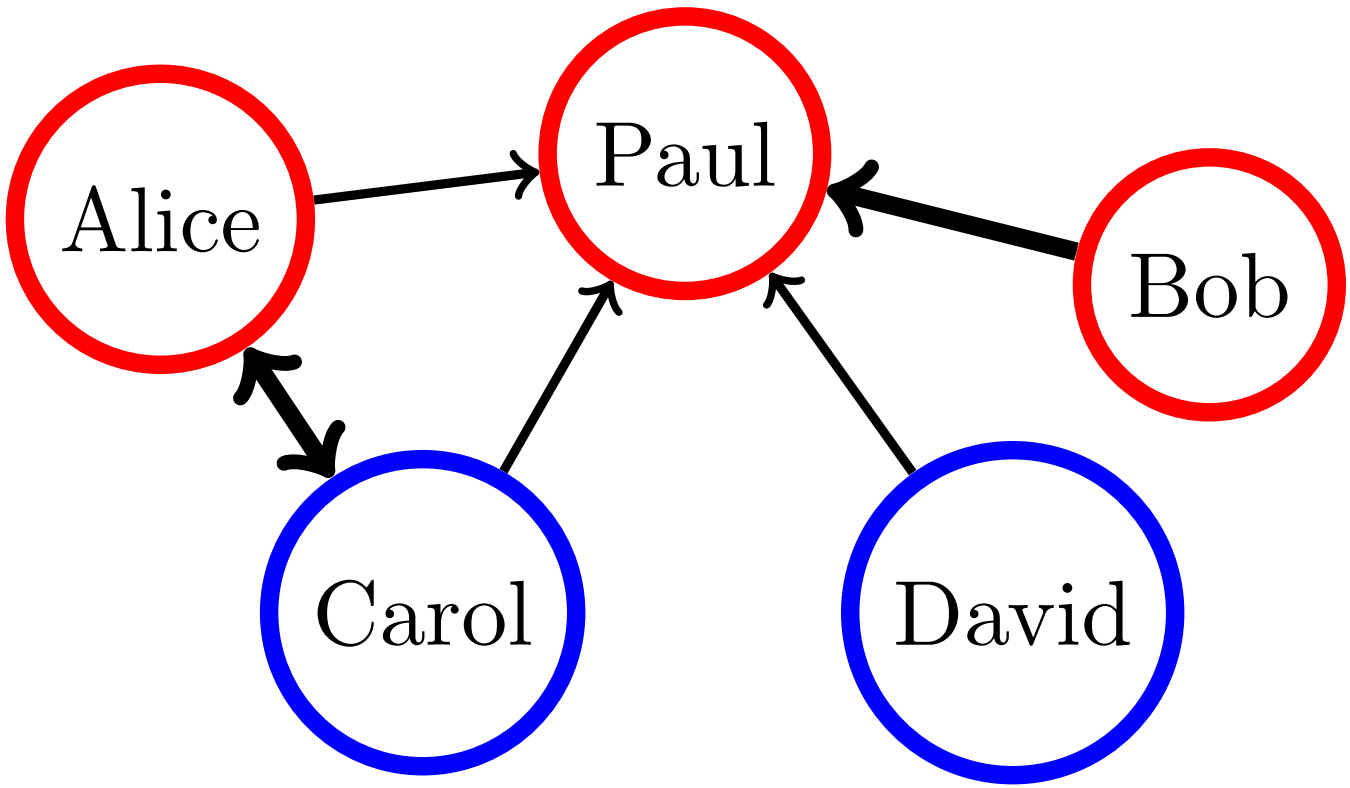


(with Sunil Bhave)

Ad: Finding Faults Fast in Smart Grids

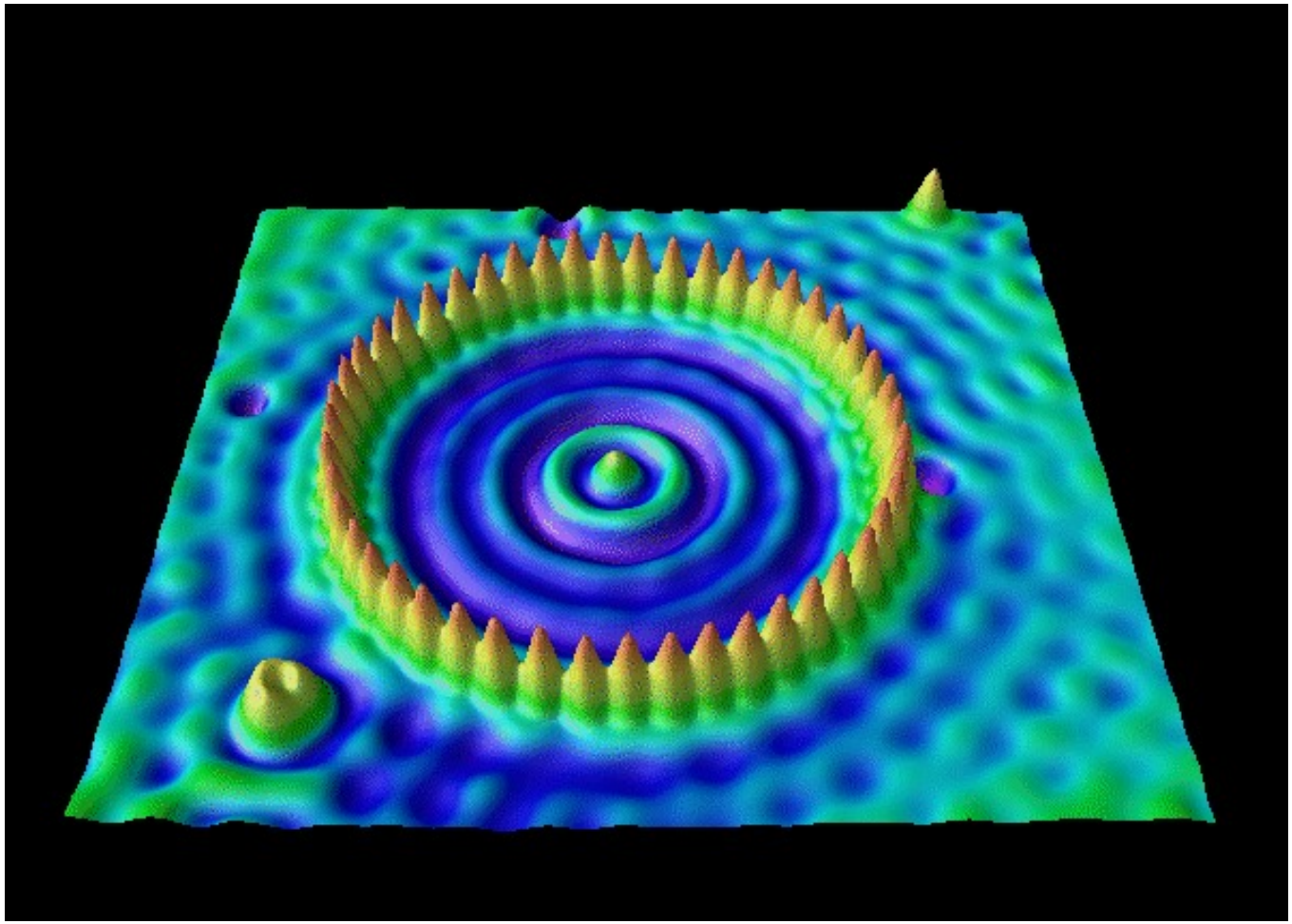
(with Birman and Van Renesse)

Ad: Opinions, Game Theory, and Eigenvalues



(with J. Kleinberg)

Ad: Nonlinear Eigenvalues and Resonances



(intermittently with Maciej Zworski)

Ad: Super-Fast PDE Solvers