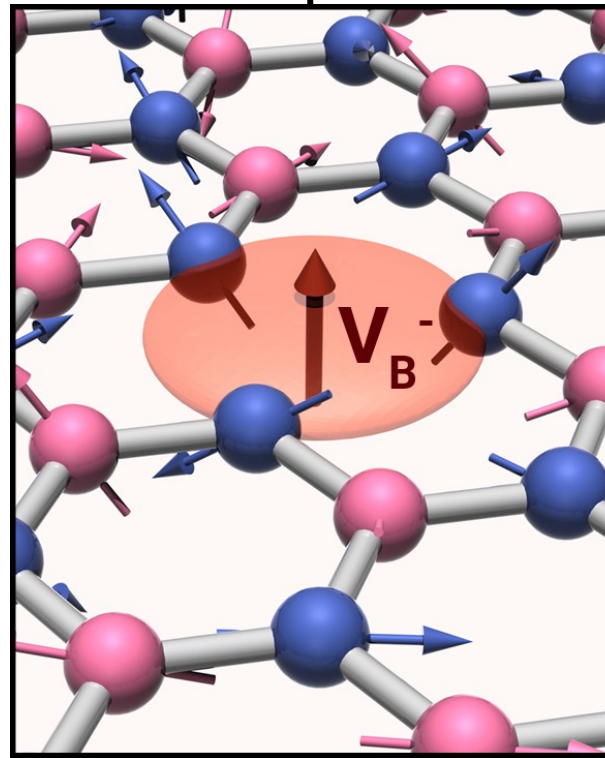
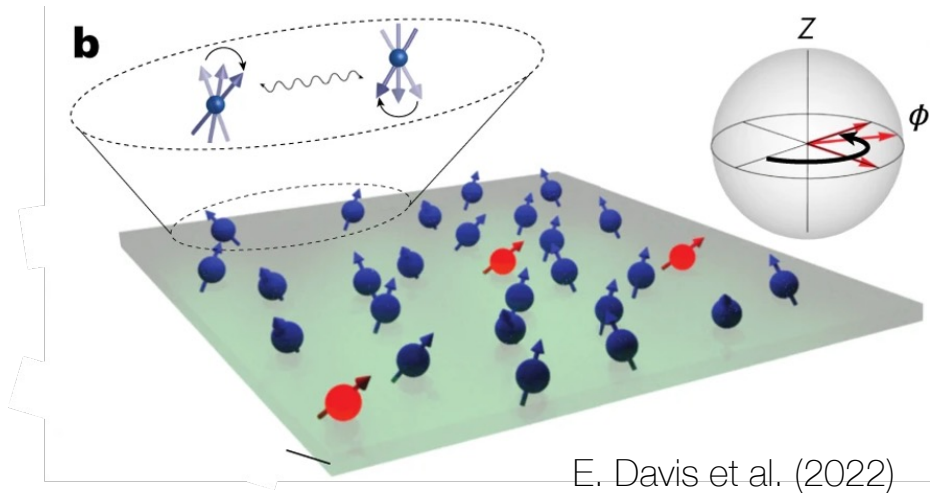


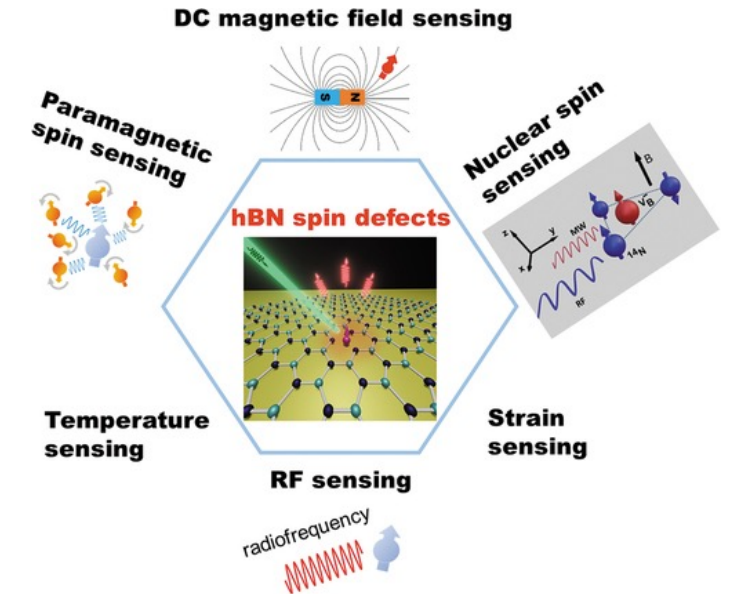
hBN defects: novel color centers in 2D materials

Quantum simulation



W. Lee et al. (2025)

Quantum sensing



Vaidya et al. 2023

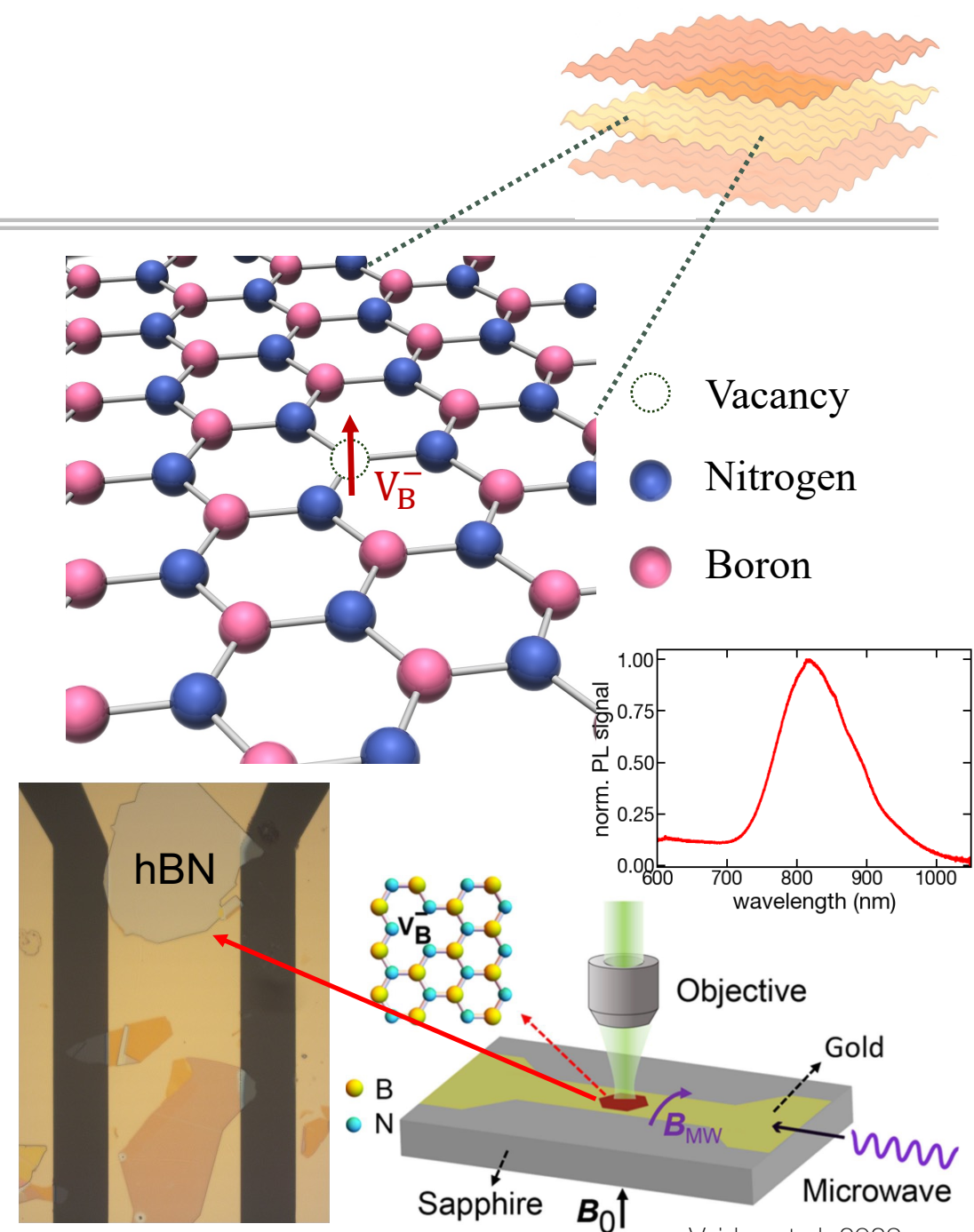
V_B^- defects in hBN

- Single missing boron atom
 - Negatively charged (-1)
 - Spin-1 system (atom-like)
 - Optical initialization & readout at RT
- High spin polarization: $P_0 \gtrsim 0.95$

W. Lee et al., Phys. Rev. Lett. 134, 096202 (2025)

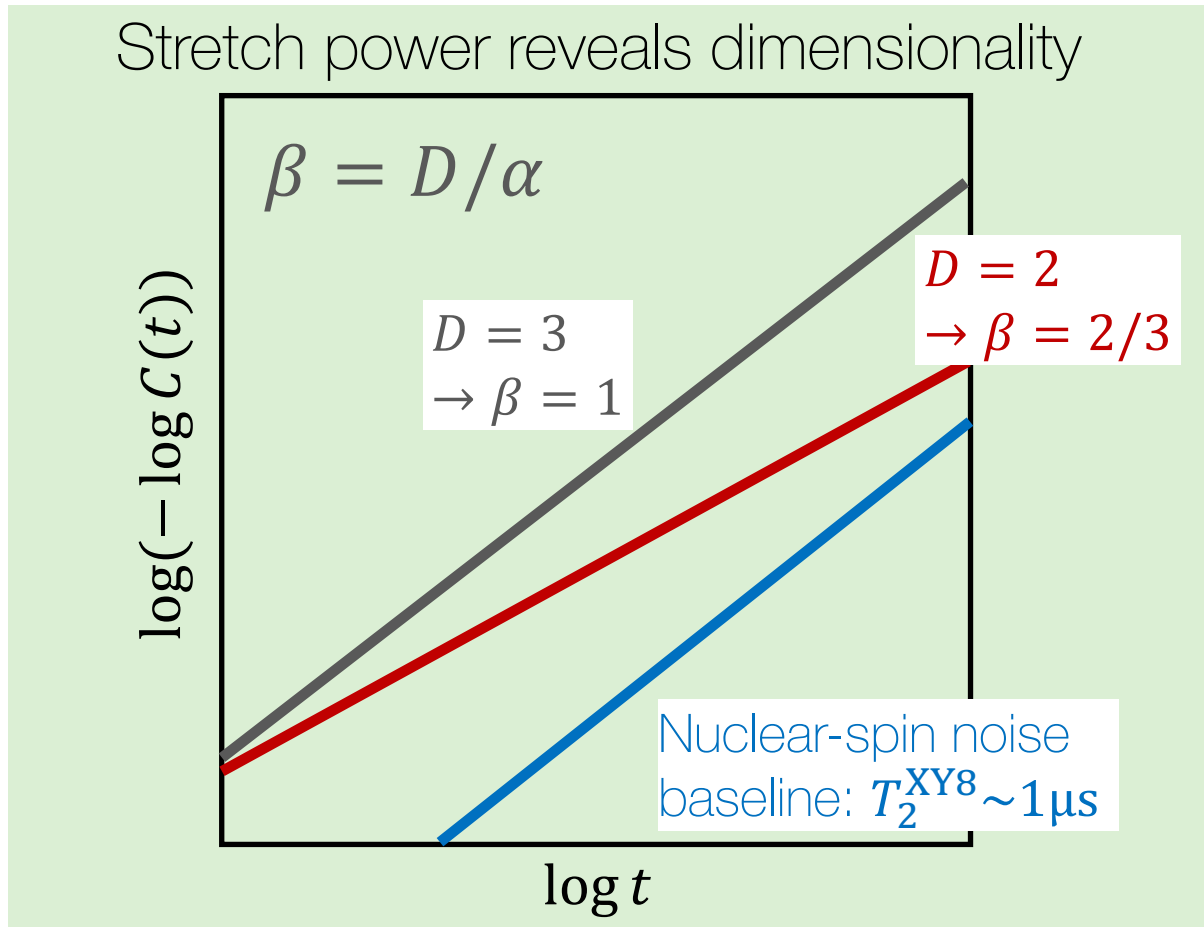
- Dipolar spin-spin interactions

$$H_{\text{dip}} = \sum_{i < j} -\frac{J_0 A_{ij}}{r_{ij}^\alpha} (S_i^z S_j^z - S_i^x S_j^x - S_i^y S_j^y)$$

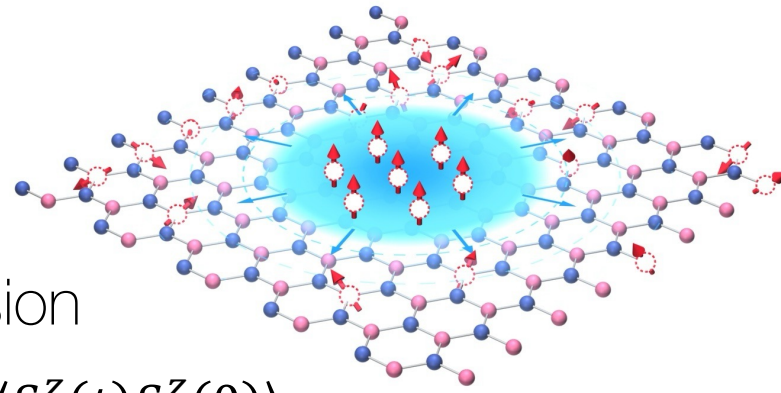


Strongly interacting 2D ensemble

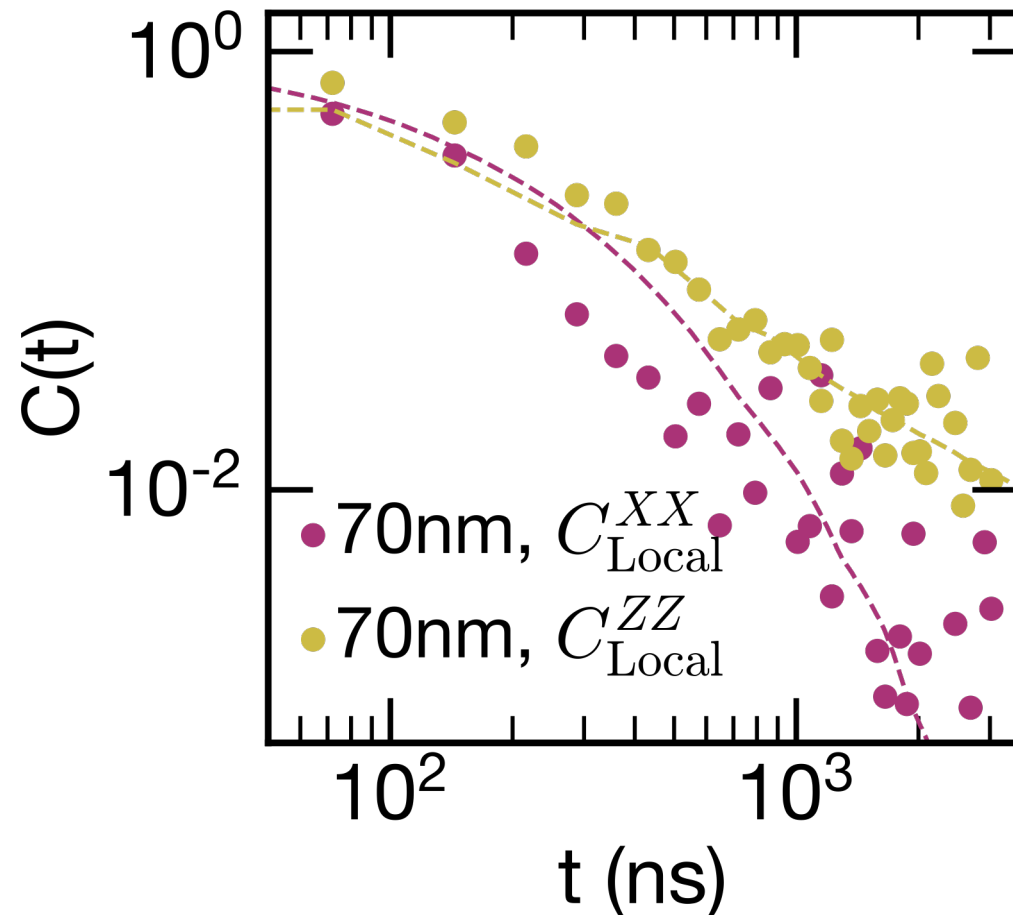
- **Geometric:** thickness < inter-defect spacing & **Dynamical:** interactions dominate dynamics
- **Many-body noise spectroscopy:** spin decoherence profile $\mathcal{C}(t) = e^{-c[J_z t]^{D/\alpha}}$



Exploration of spin dynamics in 2D

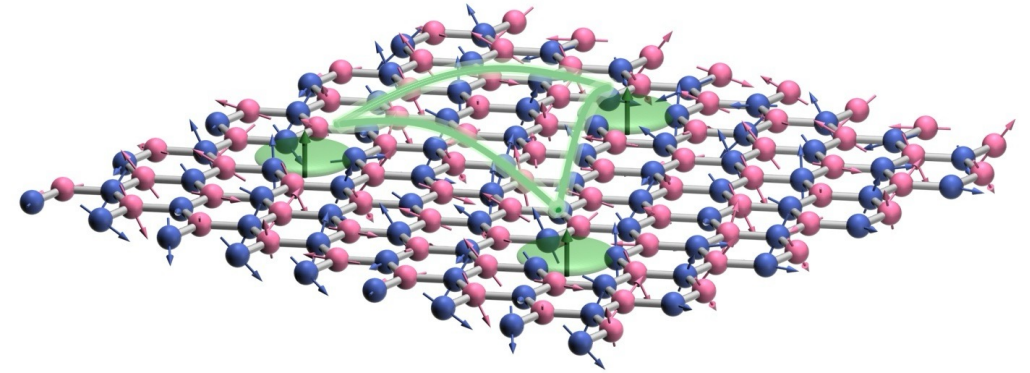


- Infinite-temperature spin transport $\rightarrow$ emergence of spin diffusion
- Local autocorrelation for survival probability of S_z : $C_{\text{Local}}^{zz}(t) = \sum_i \langle S_i^z(t) S_i^z(0) \rangle_{T=\infty}$



Outlook

- Sensing: interaction-enabled entanglement for enhanced metrology
→ local, in-situ 2D sensors with high sensitivity & spatial resolution
- Simulation: interplay of reduced dimensionality & disordered, dipolar interactions
→ 2D dipolar spin glasses, anomalous spin transport



Yao group, Harvard

