Quantum Darwinism is Generic

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Joint work with
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Classical from Quantum

How the classical world we perceive emerges from quantum mechanics?

Decoherence: lost of coherence due to interactions with environment

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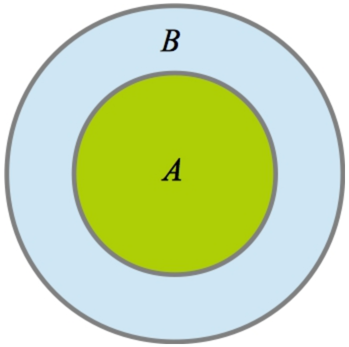
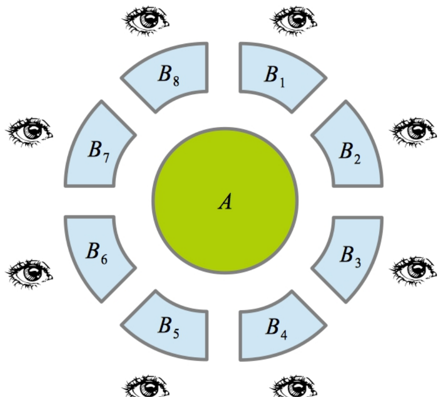
We only learn information about a quantum system indirectly by accessing a small part of its environment.

E.g. we see an object by observing a tiny fraction of its photon environment





Quantum Darwinism in a Nutshell

(Zurek '02; Blume-Kohout, Poulin, Riedel, Zwolak, ….)

Objectivity of observables: Observers accessing a quantum system by probing part of its environment can only learn about the measurement of a *preferred observable*

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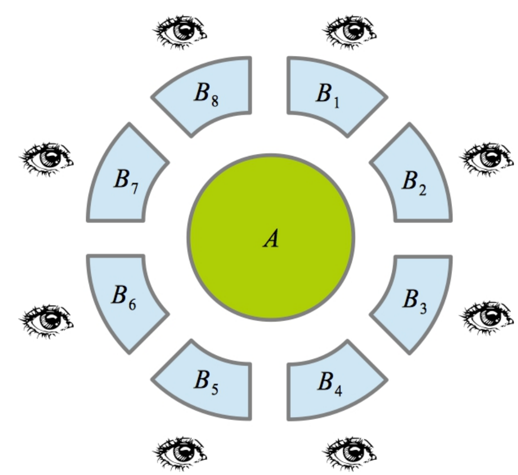
$$|\phi\rangle_{B_1,\ldots,B_k} := e^{-itH_{SE}}|\psi\rangle_S \otimes |0\rangle_E$$

ϕ_{B_j} only contains information about the measurement of $\{M_k\}_k$ on $|\psi\rangle_S$

And almost all B_j have close to full information about the outcome of the measurement $\{M_k\}_k$



Quantum Darwinism: Examples

(Riedel, Zurek '10) Dieletric sphere interacting with photon bath: Proliferation of information about the position of the sphere

⋮

(Blume-Kohout, Zurek '07) Particle in brownian motion (bosonic bath): Proliferation of information about position of the particle

Is quantum Darwinism a general feature of quantum mechanics?

No: Let $|\phi\rangle_{B_1,\ldots,B_k} := e^{-itH_{SE}}|\psi\rangle_S \otimes |0\rangle_E$

For very mixing evolutions U = $e^{-i t H}$, ϕ_{B_j} is almost maximally mixed for B_j as big as half total system size

Information is hidden (again, QECC is an example)

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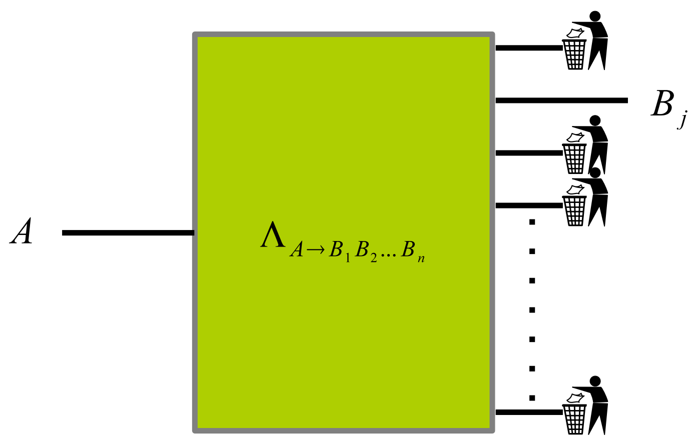
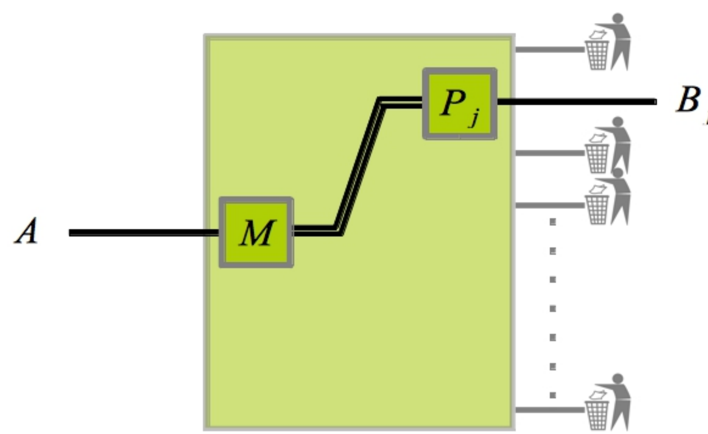
Objectivity of Observables *is* Generic

thm (B., Piani, Horodecki '13) For every $\Lambda : S \rightarrow B_1, \ldots, B_n$, there exists a measurement {M_k} on *S* such that for almost all *j,*

$$\Lambda_j(\rho) := \mathrm{tr}_{\backslash B_j} \circ \Lambda(\rho) \approx \sum_j \mathrm{tr}(M_j \rho) \sigma_{j,k}$$

$$O(d_s^3 n^{-1/3})$$





Proof by monogamy of entanglement and quantum information-theoretic techniques (blackboard)

Thanks!