Quantum State Diffusion Theory (QSD)

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Quantum state diffusion (QSD) is possibly the most sophisticated collapse interpretation on offer today. It is closely related to the Ghirardi-Rimini-Weber (GRW) style-theories (→ GRW), but it assumes that freely evolving particles are idealisations. According to QSD all physically real particles are subject to a degree of interaction with their environment. The fundamental equation of QSD is the linear master equation, which looks just like the Schrödinger equation, but with additional terms besides the usual Hamiltonian:

$d\boldsymbol{\rho} /dt = -i/h\, [\mathbf{H}, \boldsymbol{\rho}] + \Sigma_j\, (\mathbf{L_j}\, \boldsymbol{\rho}\, \mathbf{L_j}^* - \tfrac{1}{2}\, \mathbf{L_j}^*\, \mathbf{L_j}\, \boldsymbol{\rho} - \tfrac{1}{2}\, \boldsymbol{\rho}\, \mathbf{L_j}^*\, \mathbf{L_j})$, where the Lindblad operators $\mathbf{L_j}$ may or not be Hermitian.

The two limiting cases are:

1) LINDBLAD: The environmental interaction dominates and the Hamiltonian internal dynamics is negligible (these are "wide open systems" → Decoherence):
   $\mathbf{d\boldsymbol{\rho} / dt} = \Sigma_j\, (L_j\, \boldsymbol{\rho}\, \mathbf{L_j}^* - \tfrac{1}{2}\, \mathbf{L_j}^*\, \mathbf{L_j}\, \boldsymbol{\rho} - \tfrac{1}{2}\, \boldsymbol{\rho}\, \mathbf{L_j}^*\, \mathbf{L_j})$.

2) SCHRODINGER: The environmental interaction is negligible and the Hamiltonian dynamics dominates ("completely isolated systems"):
   $\mathbf{d\boldsymbol{\rho} / dt} = -i/h\, [\mathbf{H}, \boldsymbol{\rho}]$.

So QSD recovers the Schrödinger equation for the idealisation of a completely isolated system. In general, however, the full linear master equation applies, and the resulting diffusion process for the quantum state on the Bloch sphere is similar to Brownian motion in 3-d physical space. A measurement is typically modelled within QSD as a wide open system interaction with a macroscopic measuring device. Thus QSD predicts a transition from a → pure state to a → mixed state for the pointer position, which it claims solves the measurement problem.

References:

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