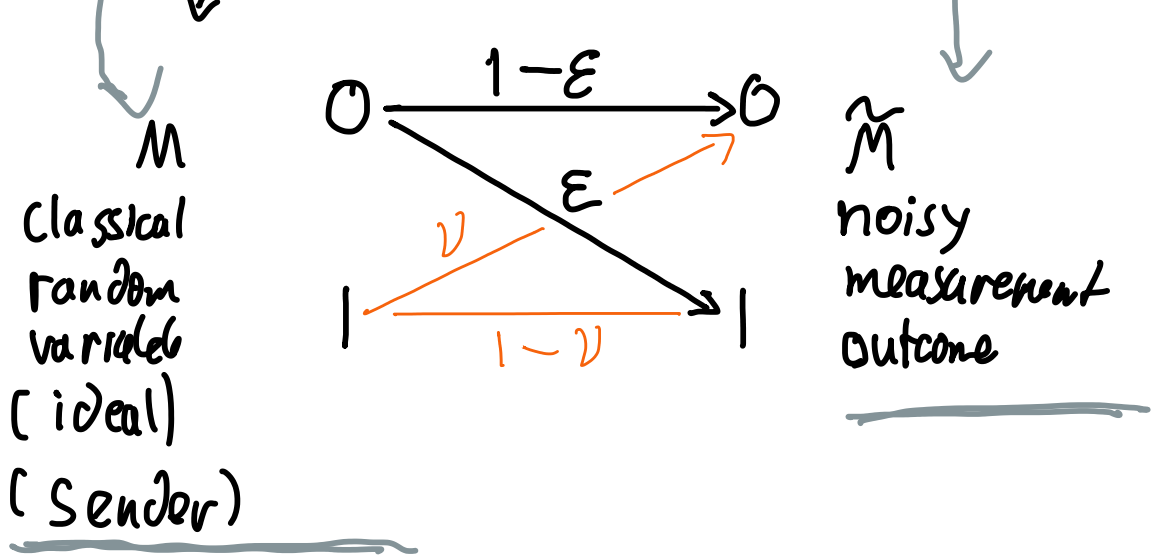
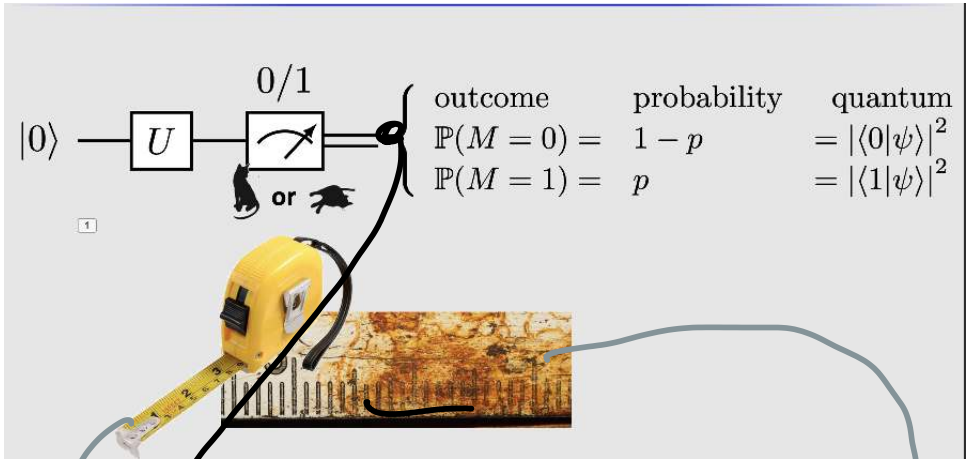


Introduction to quantum noise

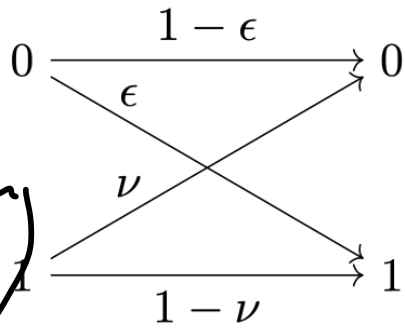
Measurement error

Qiskit Global Summer School on Quantum Simulations

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$$P(\tilde{M}=1|M=0)=\epsilon$$
$$P(\tilde{M}=0|M=1)=1-\epsilon$$
$$P(\tilde{M}=0|M=1)=\nu$$
$$P(\tilde{M}=1|M=1)=1-\nu$$



$$P_M = \begin{pmatrix} P(M=0) \\ P(M=1) \end{pmatrix} = \begin{pmatrix} 1-p \\ p \end{pmatrix}$$

$$P_{\tilde{M}} = \begin{pmatrix} P(\tilde{M}=0) \\ P(\tilde{M}=1) \end{pmatrix} = \begin{pmatrix} 1-\tilde{p} \\ \tilde{p} \end{pmatrix}$$

\tilde{p} is noisy probability

$$\begin{cases} P(\tilde{M}=0) = \sum_{m \in \mathcal{S}} (P(\tilde{M}=0|M=m)) \\ P(\tilde{M}=1) = \sum_{m \in \mathcal{S}} (P(\tilde{M}=1|M=m)) \end{cases}$$

$$\tilde{P}_M = \begin{pmatrix} P(\tilde{M}=0) \\ P(\tilde{M}=1) \end{pmatrix} = A P_M = A \begin{pmatrix} P(M=0) \\ P(M=1) \end{pmatrix}$$

$$A = \begin{pmatrix} P(\tilde{M}=0|M=0) & P(\tilde{M}=0|M=1) \\ P(\tilde{M}=1|M=0) & P(\tilde{M}=1|M=1) \end{pmatrix}$$

$$= \begin{pmatrix} 1-\epsilon & \nu \\ \epsilon & 1-\nu \end{pmatrix}$$

$$\begin{cases} \text{Ideal case} \\ \text{for no error } \nu = \epsilon = 0 \\ \Rightarrow A = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = I \end{cases}$$

Stochastic matrix

$$\sum_n A_{mn} = 1 \text{ for any } m$$

$$\begin{aligned} \tilde{p} &= P(\tilde{M}=1) = P(\tilde{M}=1|M=0)P(M=0) + P(\tilde{M}=1|M=1)P(M=1) \\ &= \epsilon(1-p) + (1-\nu)p \\ \tilde{p} &= p - \underbrace{(\nu+\epsilon)p}_{\text{offset}} + \epsilon \end{aligned}$$

Visualizing readout error

