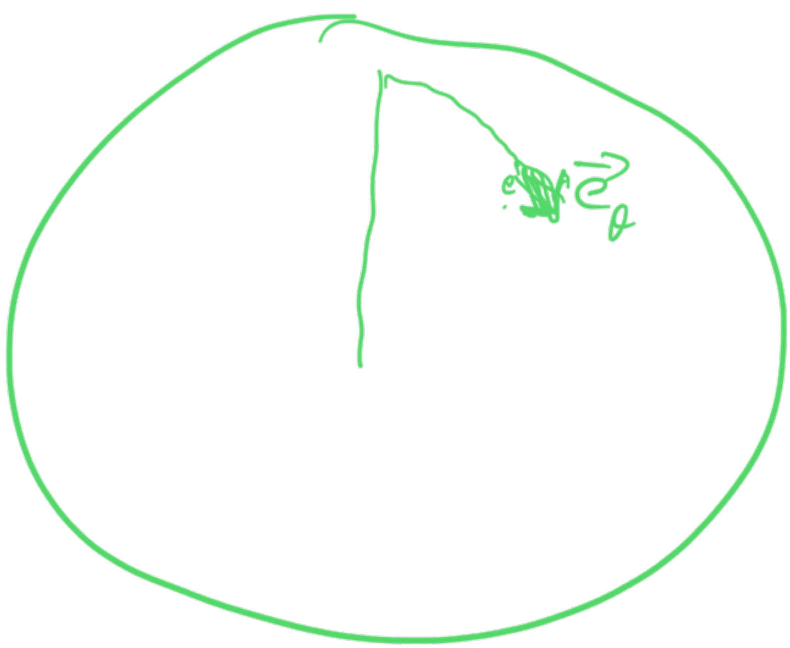
$B^z = 0$ in

TM modes



E^3

U^2

$M \qquad \begin{pmatrix} & & \\ & 1 & \\ & & 1 \end{pmatrix}$

$$R^2 = x^2 - y^2 - z^2$$

$$e_\theta \cdot e_\theta = R^2\left[-sh^2\theta + ch^2\theta\right] = R^2$$

$$e_\phi \cdot e_\phi = R^2\left(+ sh^2 \qquad \right)$$

$$\begin{pmatrix} 1 & & & \\ & 1 & & \\ & & 1 & \\ & & & 1 \end{pmatrix}$$

$$\begin{pmatrix} +1 & & & \\ & 1 & & \\ & & 1 & \\ & & & -1 \end{pmatrix}$$

$$e_{x}\cdot e_{x} = L^2\left[+ch^2 s_\theta^2 c_\phi^2 + ch^2 s_\theta^2 s_\phi^2 + ch^2 c_\theta^2 - sh^2\right]$$

$$= L^2$$

$$R^k{}_{i\ell m} = g^{ks} R_{si\ell m}$$

$$= [D_\ell, D_m]^k{}_i$$

$$R_{im} = R^k{}_{ikm}$$

$$R = g^{ni} R_{im}$$

scalar

$$S = \int \text{scalar } d^4x$$

$$\int \sqrt{\quad} \, d^4x$$

$$= \int \text{scalar}\, \underbrace{\sqrt{g}\; d^4x}$$

$$= \int R \sqrt{g}\, d^4x$$

$$g = |\det g|$$

$$g = g_{ik}$$

$$S_{EH} \approx \underline{m_p^2} \int R \sqrt{g}\, d^4x$$

tiniest change

$$0 = \delta S$$

$$\approx G \int \delta(G\sqrt{g})\, d^4x$$

$$\Downarrow$$

Einstein's eq.

$$R_{ik} = \frac{1}{2} g_{ik} R$$

empty space

Ricci

$$\delta S_m = \frac{1}{2c} \int T^{ik} \sqrt{g}\, \delta g_{ik}\, d^4x$$

$$R_{ik} - \frac{1}{2} g_{ik} R = \frac{8\pi G}{c^4} T_{ik}$$

geometry

S.M.
matter
energy.

$g' = \eta$ is a
small 4-volume

small

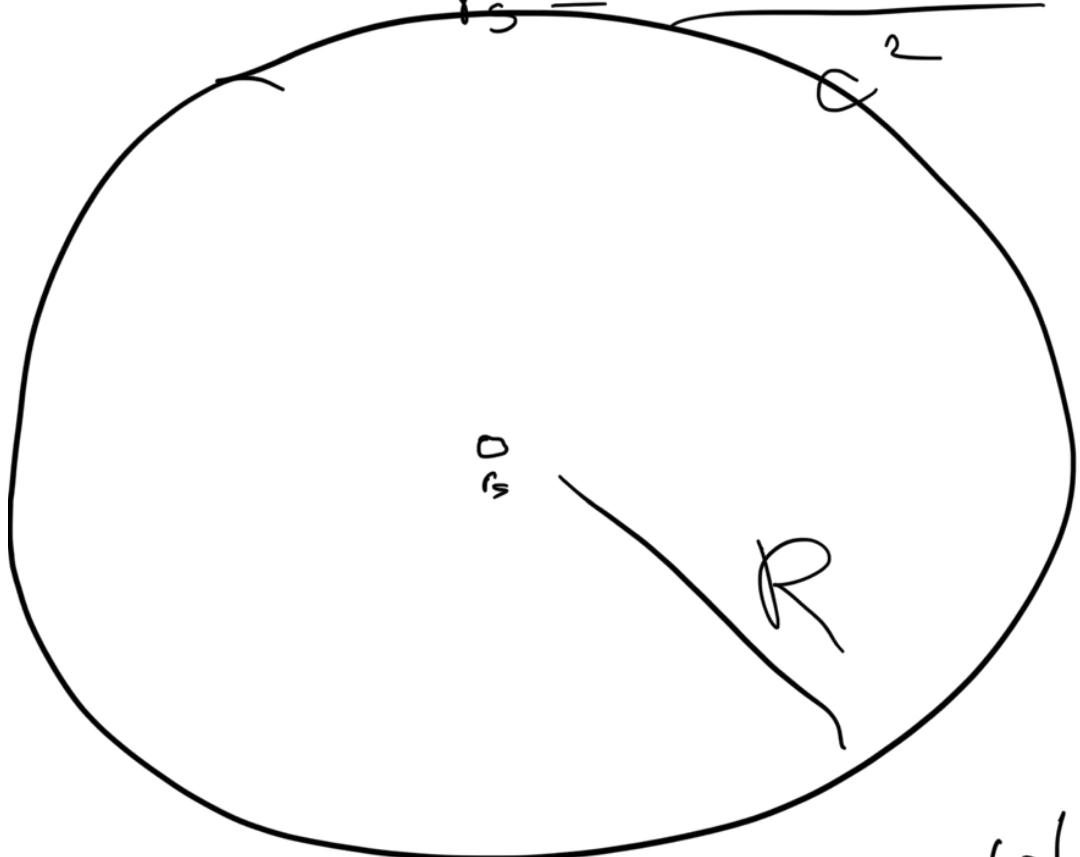
$$g = \begin{pmatrix} -x^2 & & & \\ & a^2 & & \\ & & a^2 & \\ & & & a^2 \end{pmatrix}$$

$$ds^2 = g_{ik}\, dx^i dx^k$$

ds^2 r

~~1M~~

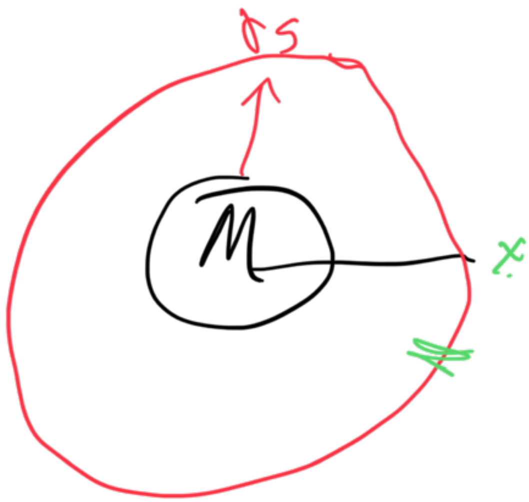
$$r_s = \frac{2MG}{c^2}$$



S. Schwarzschild

$$r_b < r_h = r_s = \frac{2mG}{c^2}$$

$$dt = \frac{d\tau}{\sqrt{g_{\dots}}} = \frac{d\tau}{\sqrt{1 - \frac{2MG}{\dots}}}$$



$$= \frac{d\tau}{\sqrt{1 - \frac{r_s}{r}}}$$

$$\underbrace{dt}_{} >> \underbrace{d\tau}_{}$$

$$T = \begin{pmatrix} -\rho c^2 & & & \\ & p & & \\ & & p & \\ & & & p \end{pmatrix}$$

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right)$$

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \cancel{\frac{c^2 k}{a^2}}$$

$$0$$

$$\frac{d\rho}{da} = -\frac{3}{a}\left(\rho + \frac{p}{c^2}\right)$$

$$\rho = \rho_0 \left(\frac{a_0}{a}\right)^{3(1+w)}$$

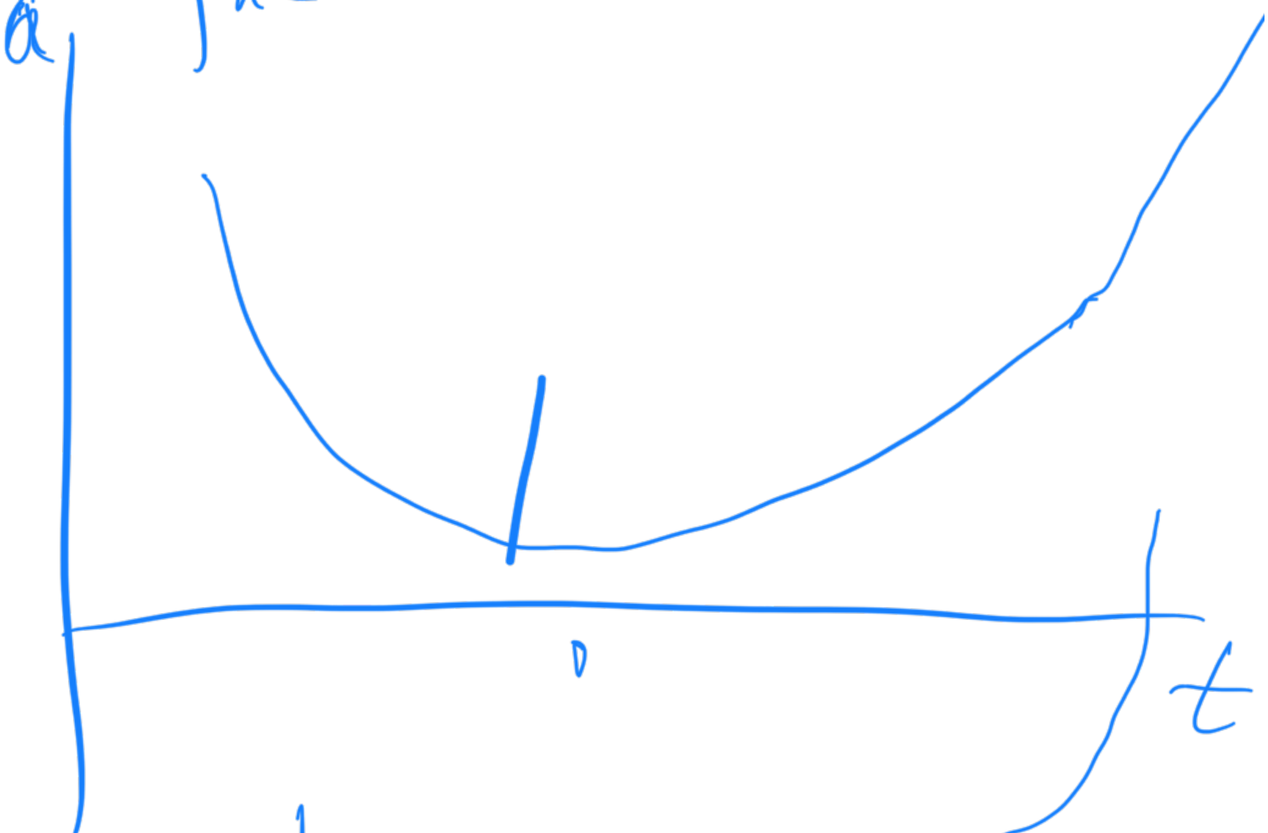
$$p = c^2 w \rho$$

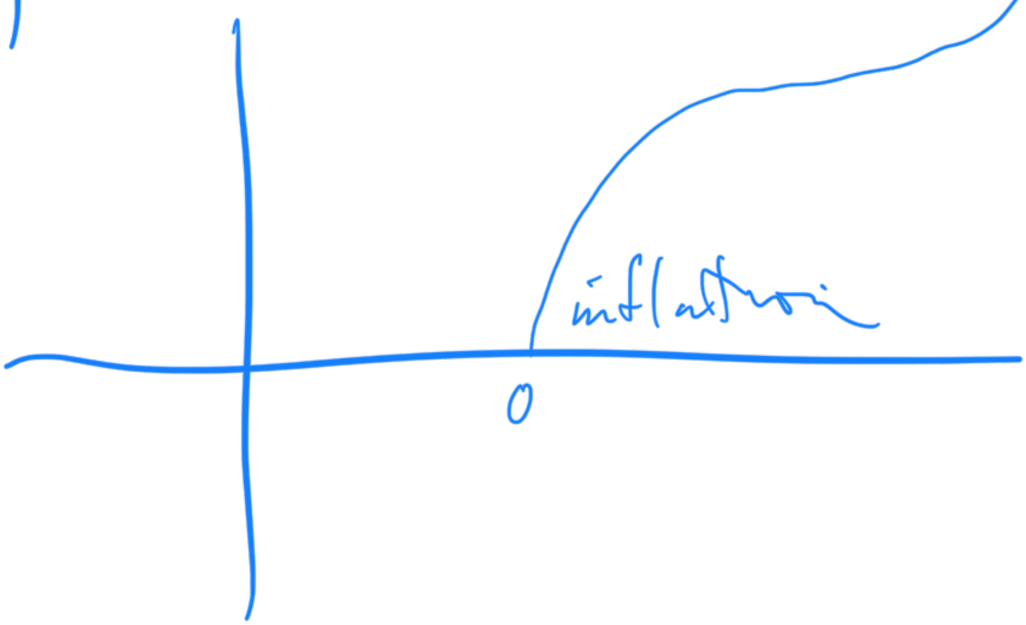
$$\rho_m = \frac{\rho_0}{a^3}$$

if ρ is due to particles

$$\rho_r = \frac{\rho_0}{a^4}$$

$$\rho_{de} = \rho_0$$





$$\rho = \frac{\rho_{r0}}{}$$

r $\quad a^4$

$$\vec{E}(\rho)\, e^{in\phi}\, e^{i(kz-\omega t)}$$

$$\vec{B}(\rho)\, e^{in\phi}\, e^{i(kz-\omega t)}$$

$$\vec{E}(\rho) = E^{\rho}\hat{\rho} + E^{\phi}\hat{\phi} + E^{z}\hat{z}$$

TE $\quad \vec{E}$ is transverse

$$E^{z} = 0$$

TM $\quad B$ is Transverse

$$B^z = 0$$

$$E^z(r) = 0$$

$$E^\phi(r) = 0$$

$$B^\rho(r) = 0$$

$$f(x) = (x^2 - \pi^2)^2$$

$f(-x) = f(x)$

$[-\pi, \pi]$

$$\frac{1}{2\pi i} \oint \frac{(z'-1)^n}{z'+1} dz'$$

$$= (z'-1)^n \Big|_{z'=-1}$$

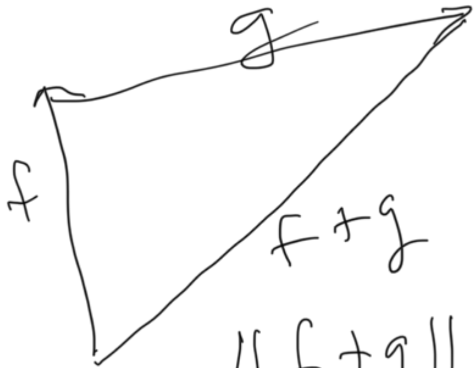
$$= (-2)^n$$

$$\langle \psi | x | \psi \rangle$$

$$\langle \psi | p | \psi \rangle$$

$$|(f,g)|^2 \leq (f,f)(g,g)$$

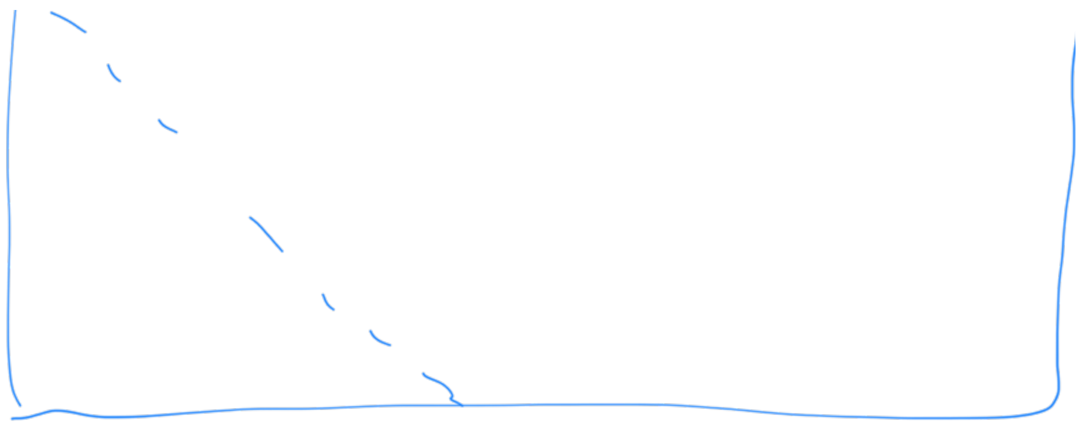
$$|\langle f|g\rangle|^2 \le \langle f|f\rangle\langle g|g\rangle$$



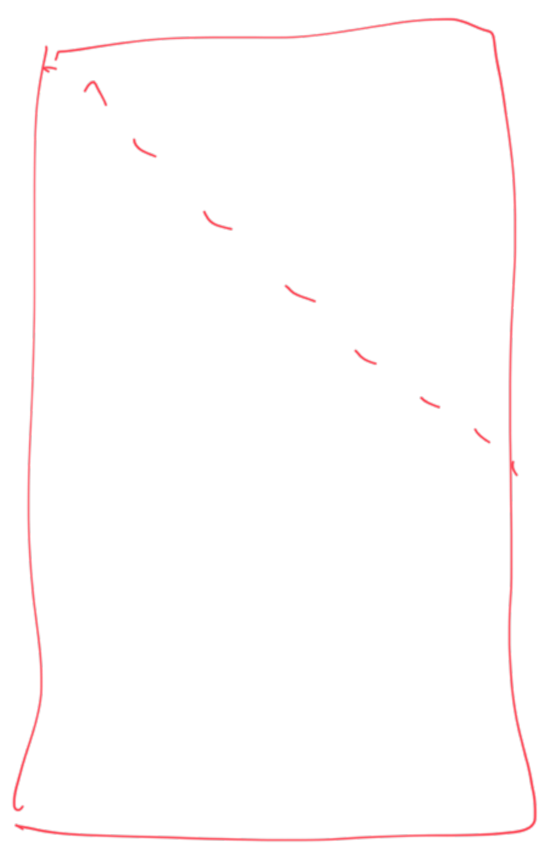
$$\|f+g\| \le \|f\| + \|g\|$$

$$0 \le \frac{|(f,g)|}{\|f\|\,\|g\|} \le 1$$

$$\frac{|(f,g)|}{\|f\|\,\|g\|} = \cos(\theta)$$



$$A = U\Sigma V^{\dagger}$$



$$\psi(x) = \langle x | \psi \rangle$$

$$\rho^\dagger = \rho \qquad \mathrm{Tr}(\rho) = 1$$

$$\langle \psi | \rho | \psi \rangle \geq 0$$

$$\rho = \sum_{k=1}^{N} p_k |k\rangle\langle k|$$

$$= \int dk\, \rho(k) |k\rangle\langle k|$$

$$\mathrm{Tr}\rho = 1 = \mathrm{Tr}\left(\sum p_k |k\rangle\langle k| \right)$$

$$= \sum p_k = 1$$

$$\rho = |\psi\rangle\langle\psi|$$

'

$$\psi(x) = \langle x | \psi \rangle$$

$$[A, B] = i\hbar [A, B]_{PB}$$

$$[q, p] = i\hbar$$

$$[q, p]_{PB} = 1 \cdot 1 - 0 \cdot 0 = 1$$

$$e^{\frac{a}{3}} e^{\frac{b}{3}} e^{\frac{a}{3}} e^{\frac{b}{3}} e^{\frac{a}{3}} e^{\frac{b}{3}}$$

$$\simeq e^{a+b}$$

$$e^{-iT(K+V)} \simeq e^{-i\epsilon K} e^{-i\epsilon V} e^{-i\epsilon K} e^{-i\epsilon V}$$

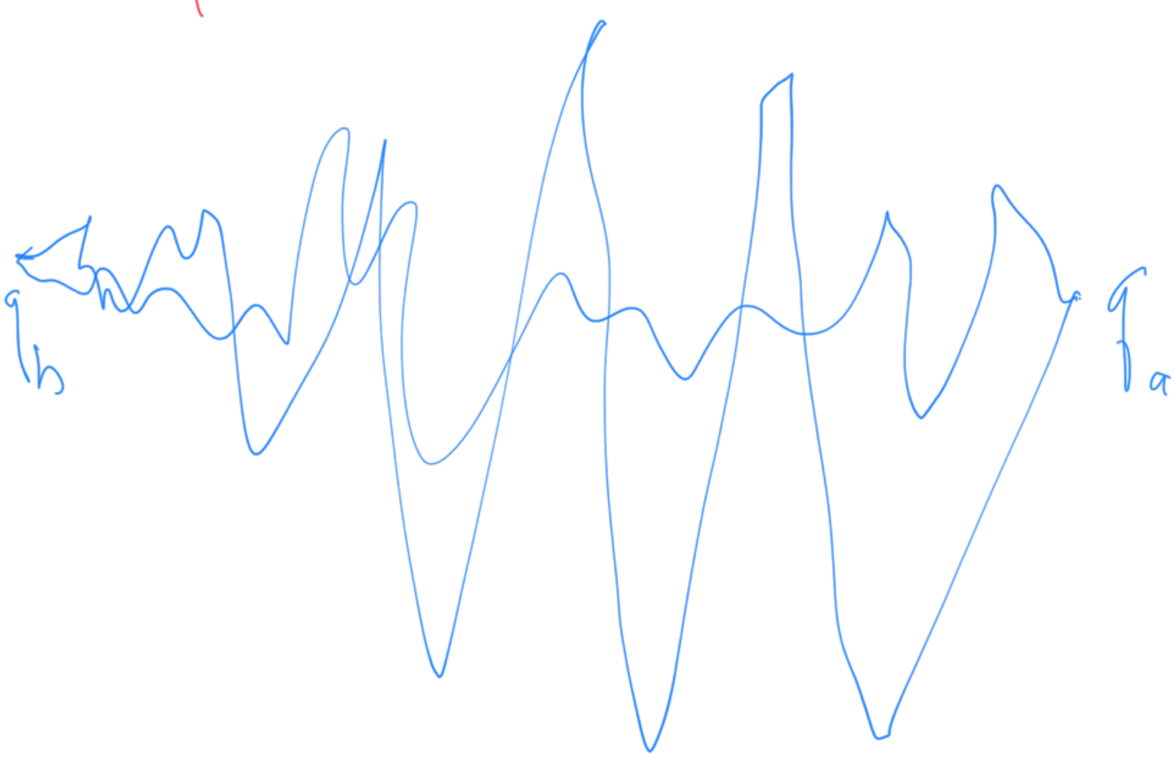
$$\ldots \ldots \; e^{-i\epsilon K} e^{-i\epsilon V}$$

$$\epsilon = \frac{T}{n} \qquad n \to \infty$$

$$e^{-\beta(K+V)} = e^{-\frac{\beta}{n}K} e^{-\frac{\beta}{n}V} \cdots e^{-\frac{\beta}{n}K} e^{-\frac{\beta}{n}V}$$

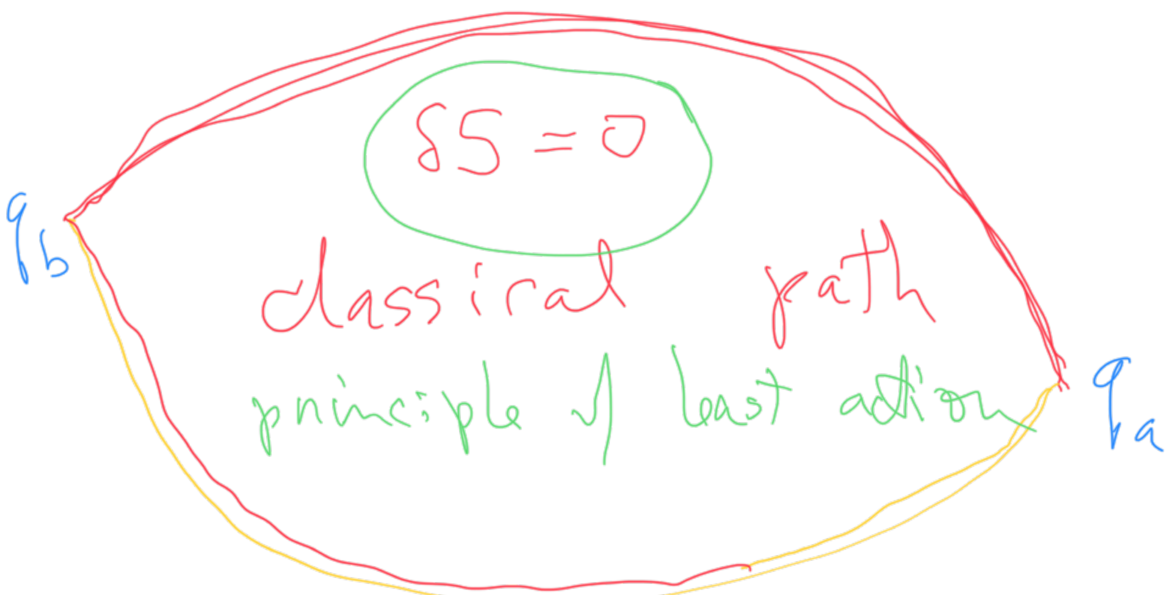
$$n \to \infty$$

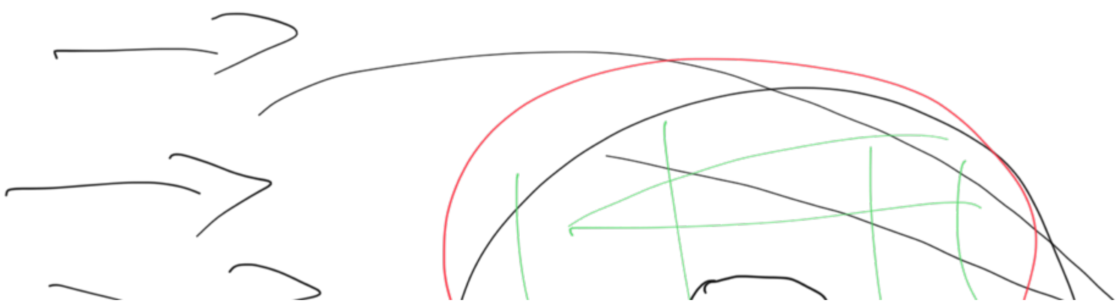
$$\beta = \frac{1}{kT}$$

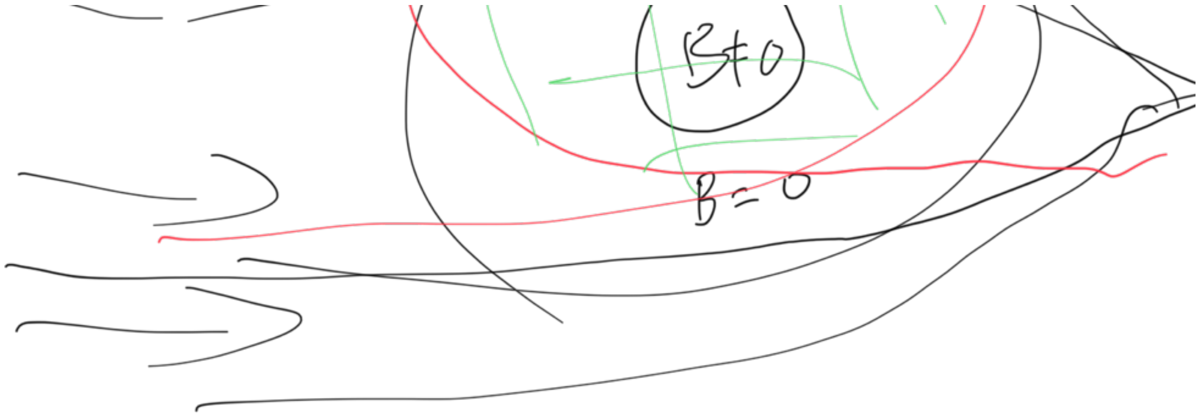


$$\int e^{i\frac{S}{\hbar}} Dq$$

$$= \langle q_b | e^{-\frac{itH}{\hbar}} | q_a \rangle$$



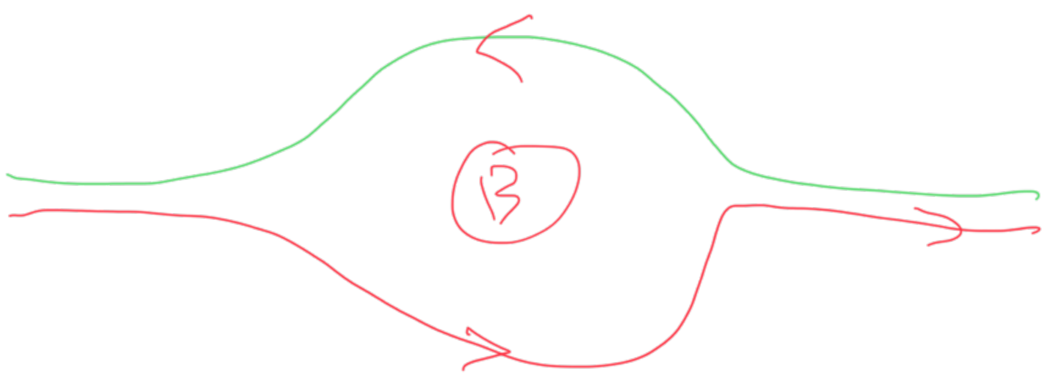




$$\frac{S}{\hbar} = \frac{1}{\hbar}\int \left[\frac{1}{2} m \dot{q} + eA\right]\cdot dq$$

$$\oint \frac{e}{\hbar} A \cdot dq = \int \frac{e}{\hbar} \nabla \times A \cdot ds$$
$$= \int \frac{e}{\hbar} B \cdot ds = \frac{e}{\hbar}\Phi$$

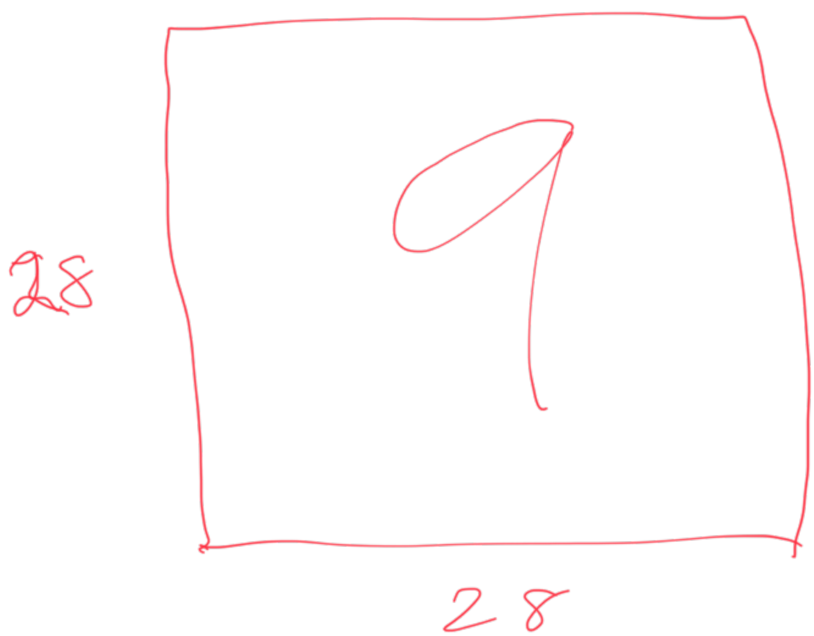
$$\Delta S = \frac{e\Phi}{\hbar}$$



$\vec{A} \neq 0$

$B = 0$

$E = 0$



$28^2 = 784$