Information Missing Puzzle, Where Is Hawking's Error?

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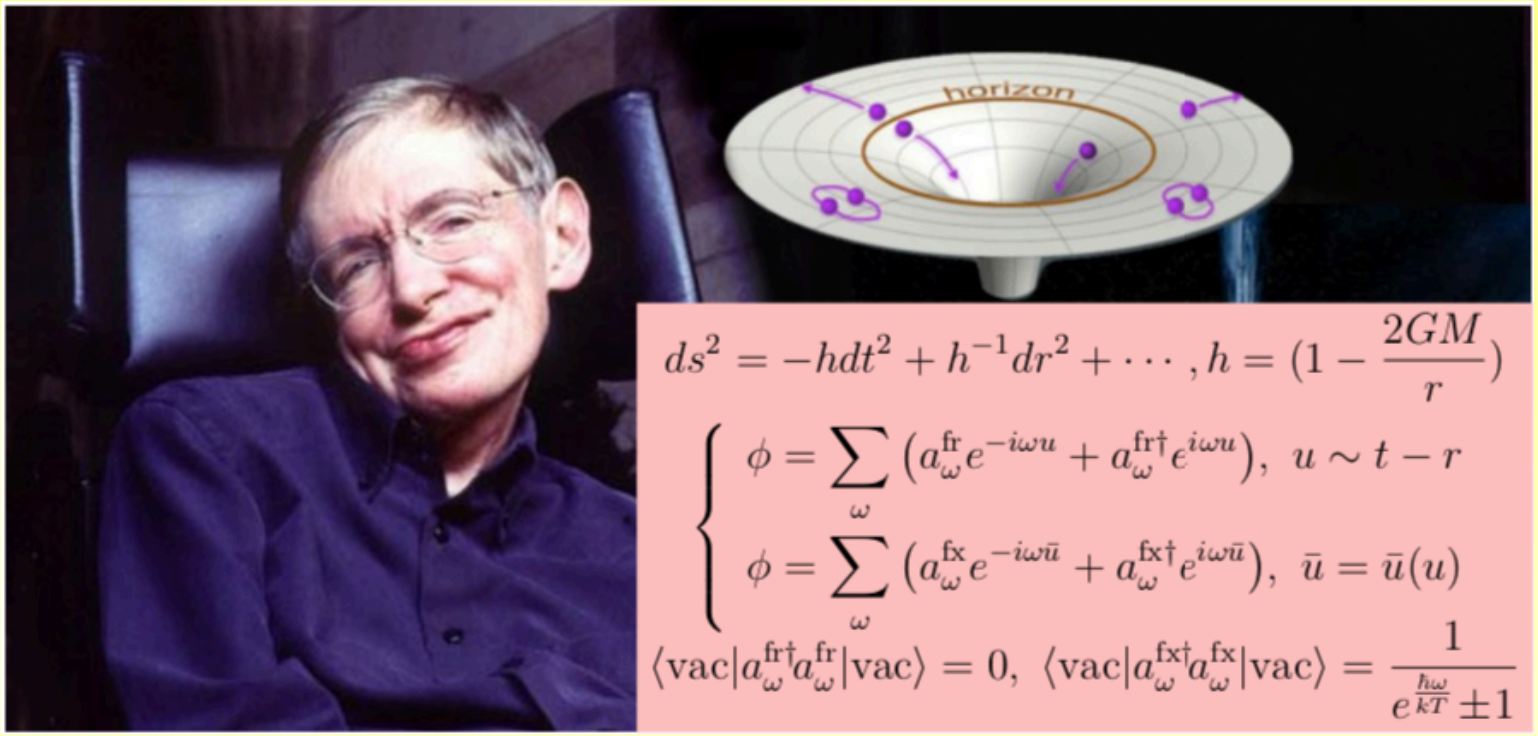
basing on NPB.917(2017)178, NPB930(2018)533, NPB941(2019)665, 1812.06777 & honorable mentioned work in GRF2019 essay competition.

July 5, 2019

Hawking: blackholes (BH) radiate thermodynamically



- ♠ By Hawking, this radiation (HR) follows from the fact that, fixed position and freely falling observer have different vacuum def. for QFT
- ♣ therm. feature of HR violates the unitarity principle of isolated system, thus Information Missing Puzzles (IMP)
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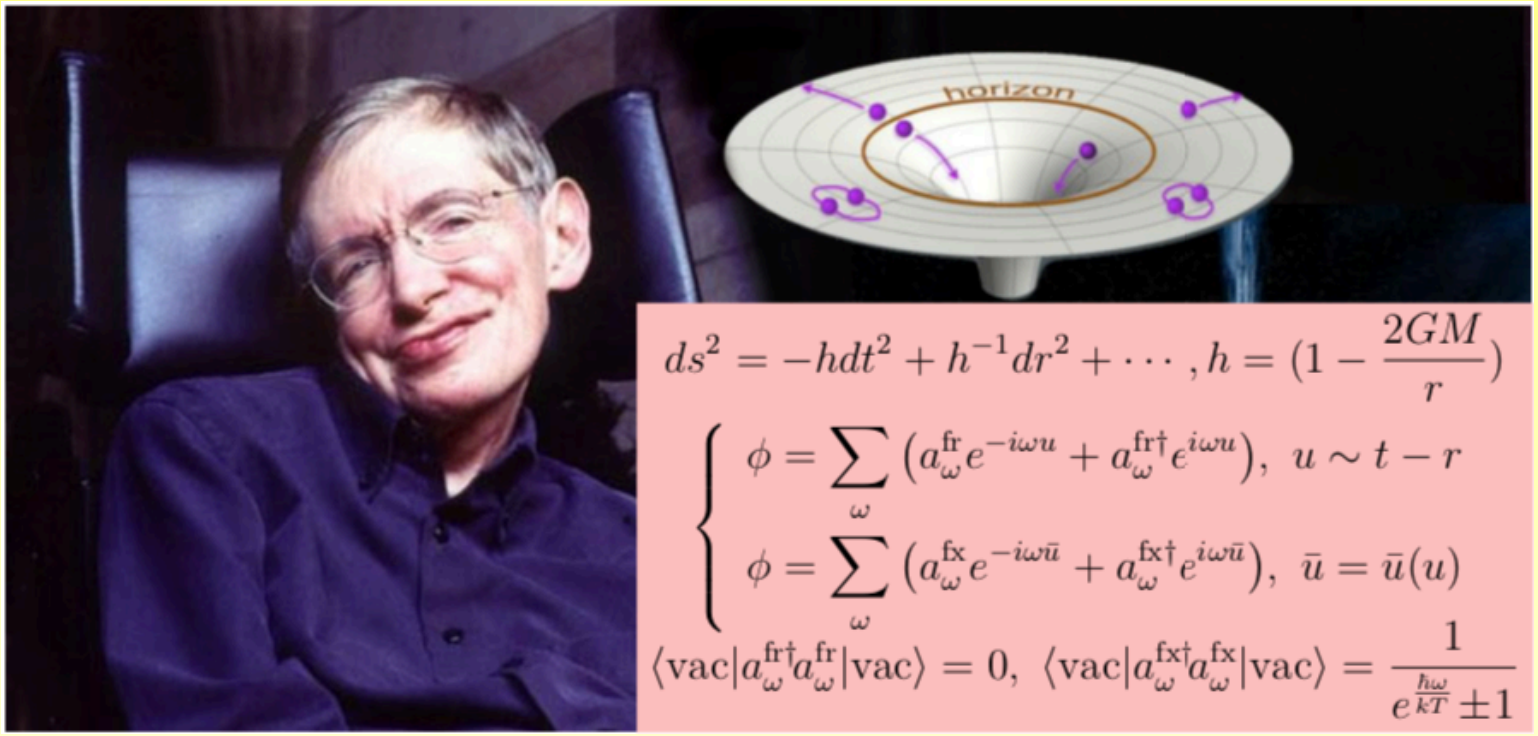

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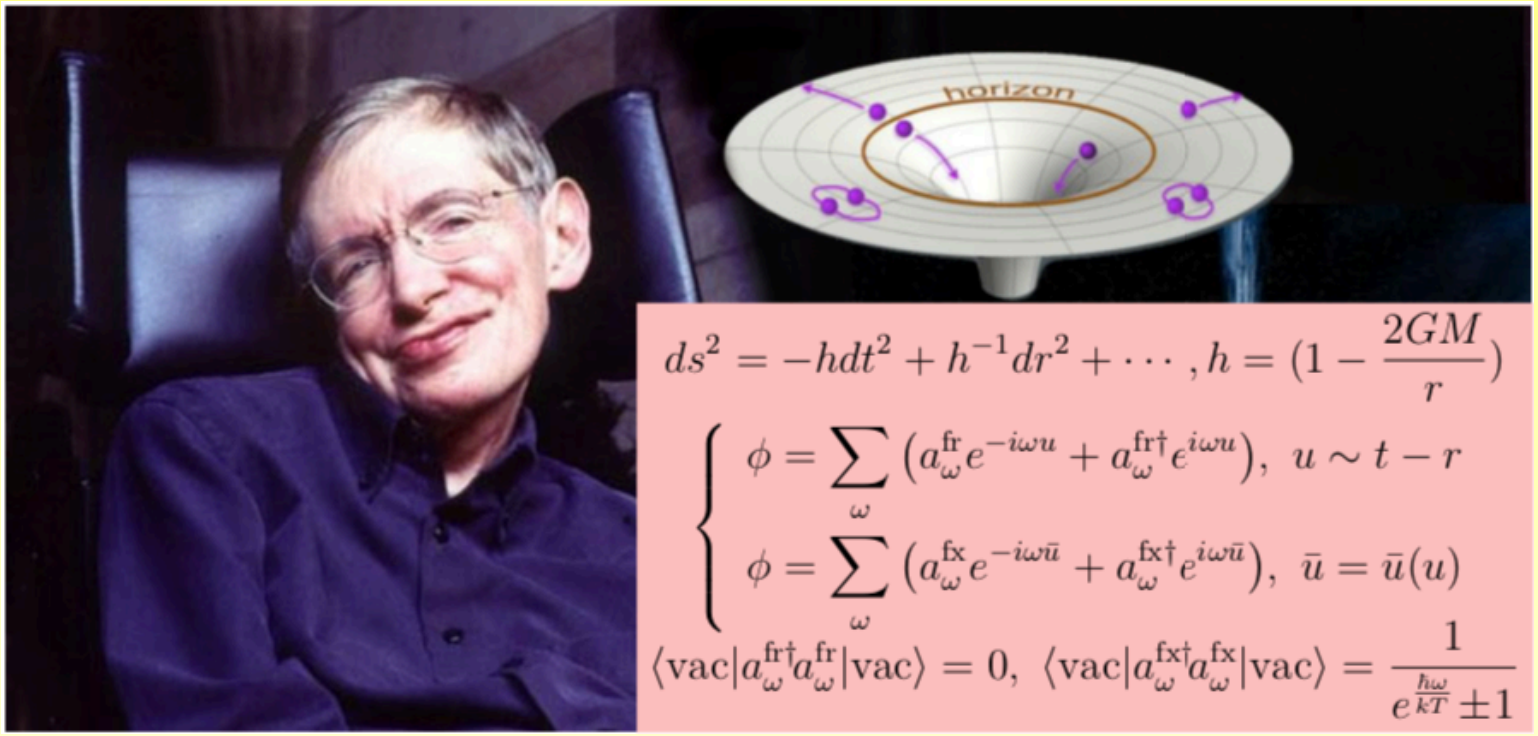

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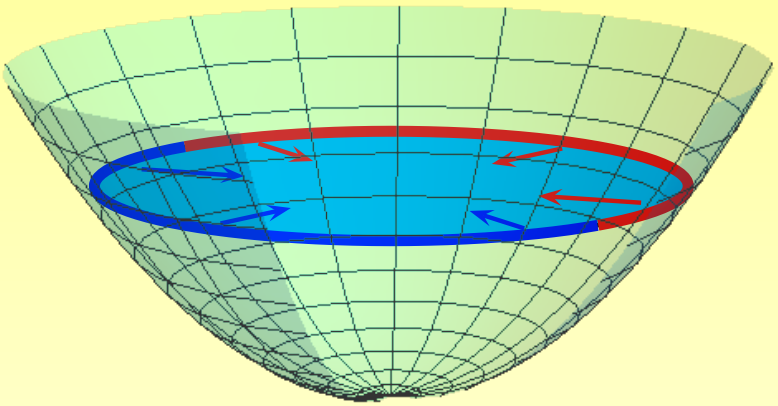
Decl. singularity theorem (ST) is over-interpreted (OI)

♠ Matters consisting of or falling into a BH(s.symm.) arrive on the central pt. in finite proper time, but not accumulate and form static singularities, they go across each other and oscillate there.



$$ds^2_{\rm inn}=-d\tau^2+a^2\Big[\frac{d\varrho^2}{\kappa}+\varrho^2 d\phi^2\Big] \quad (1)$$

$$\kappa(\varrho)=1+\varrho^2\ell^{-2}-2GM(\varrho)$$

$$\boxed{a(\tau)=\cos[\ell^{-1}\tau],}\ \varrho\leqslant\varrho_{\rm hor}$$

$$ds^2_{\rm out}=-hdt^2+h^{-1}dr^2+r^2d\phi^2$$

Ex., AdS2+1 dust stars, (OI) ST, static conical singularity is the final. However, Eins.Eq

$M(\varrho)_{\max}=M_{\rm tot}$, $M(\varrho)$ expr' multiplicity accounts for the microscopic origin of BH entropy

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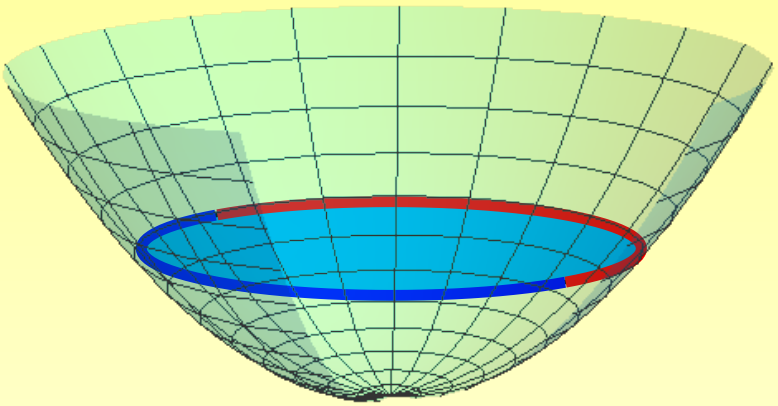

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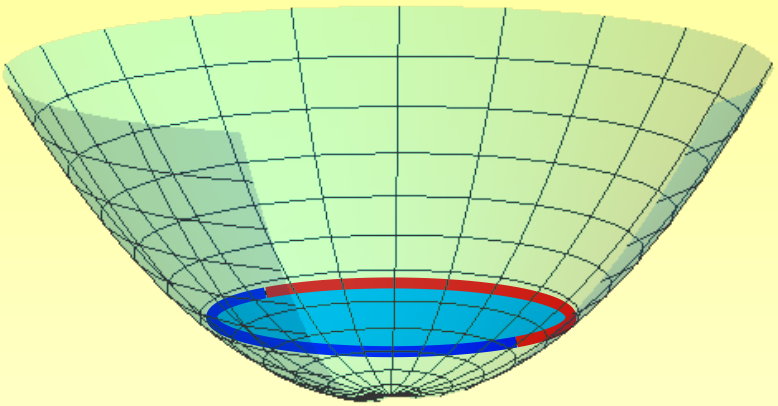

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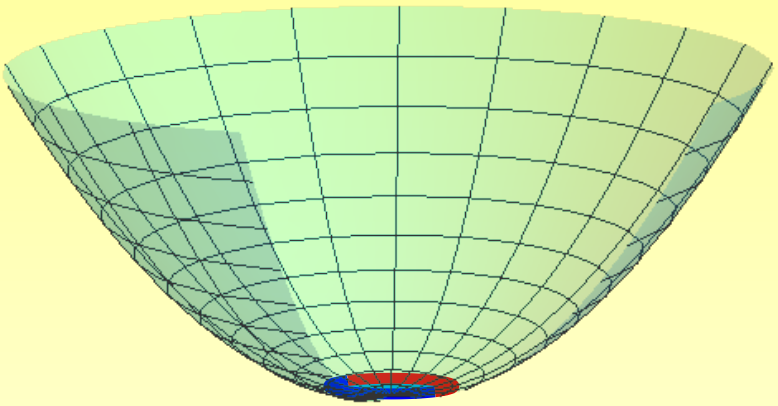

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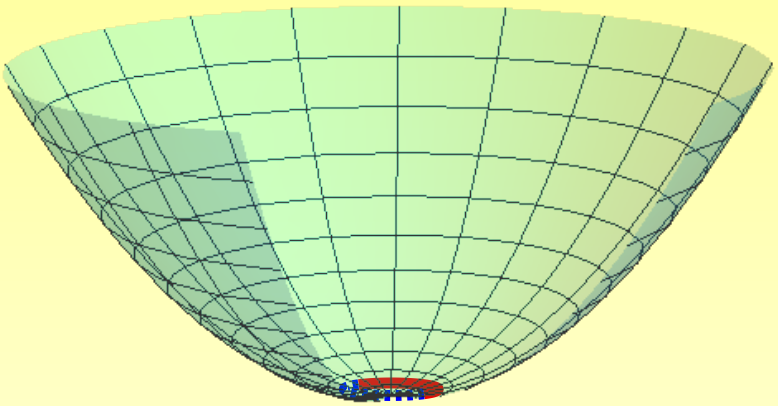

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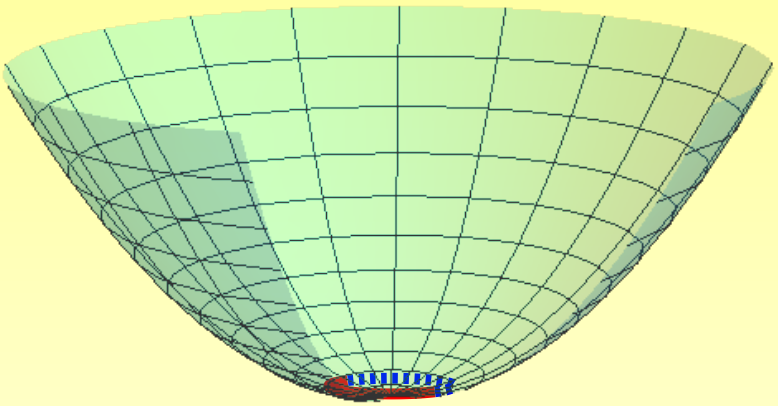

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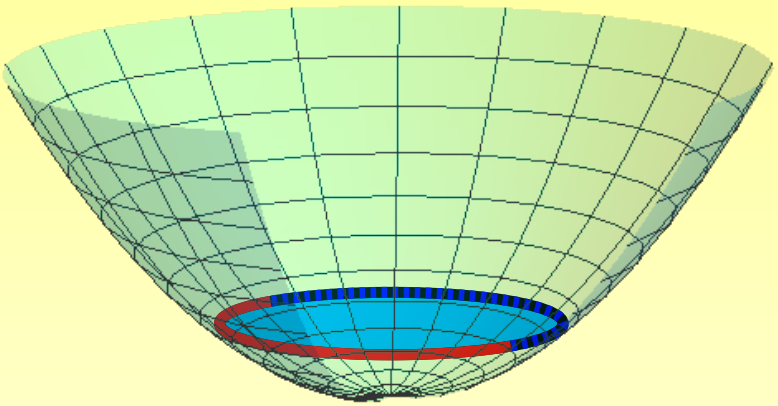

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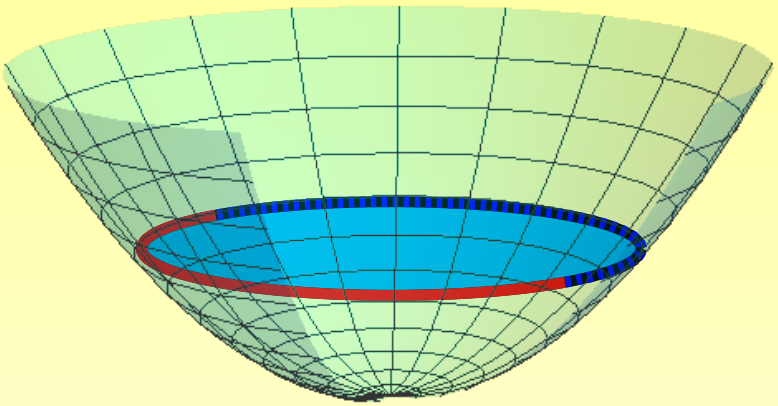

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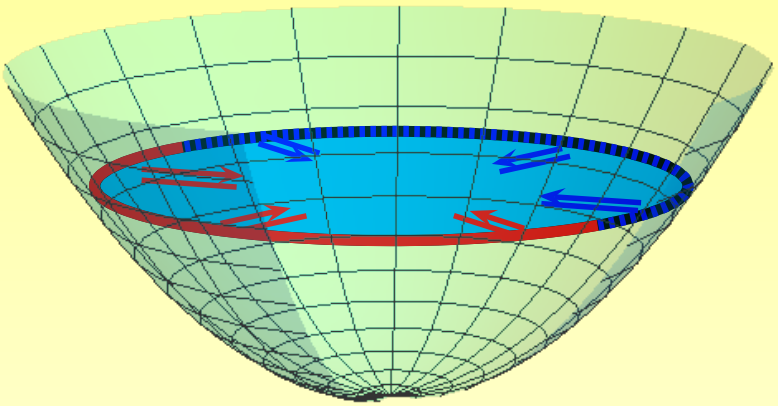

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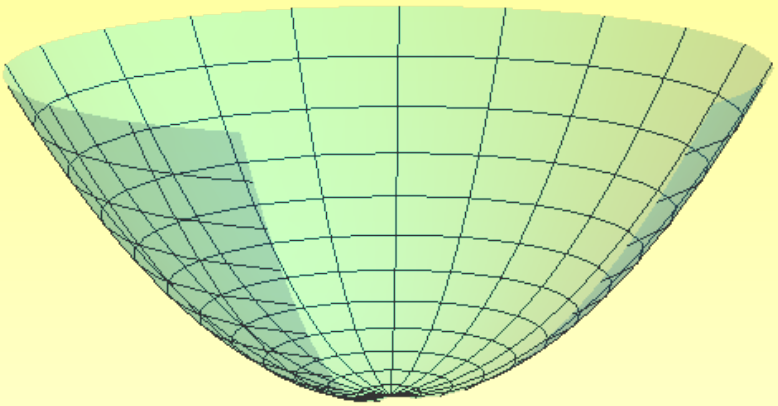

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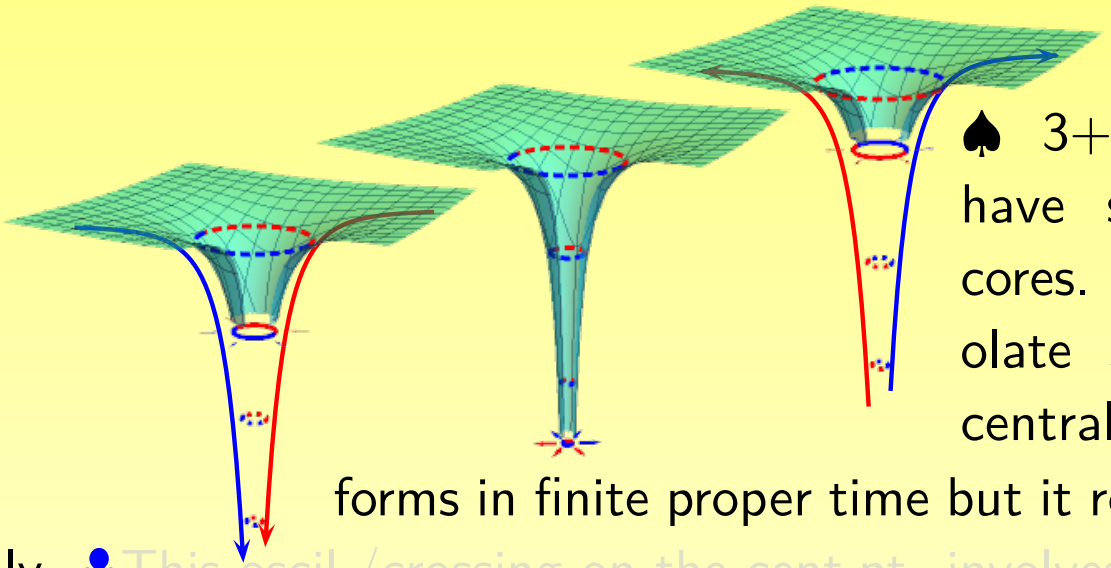
♣ Just like ordinary atoms, BHs with oscillatory core will spontaneously radiate, indistingushible from HR

The OIST in 3+1D Schwarzschild BHs



♠ 3+1Schwz.BHs also have similar oscillation cores. This does not violate ST. Because the central singularity indeed forms in finite proper time but it resolves immediately. ♣This oscil./crossing on the cent.pt. involves not any unknown QG eff, just de'Broglie waves superposition and independent propagation when encounters. In QFT languages

$$S = 1 + iT \tag{2}$$

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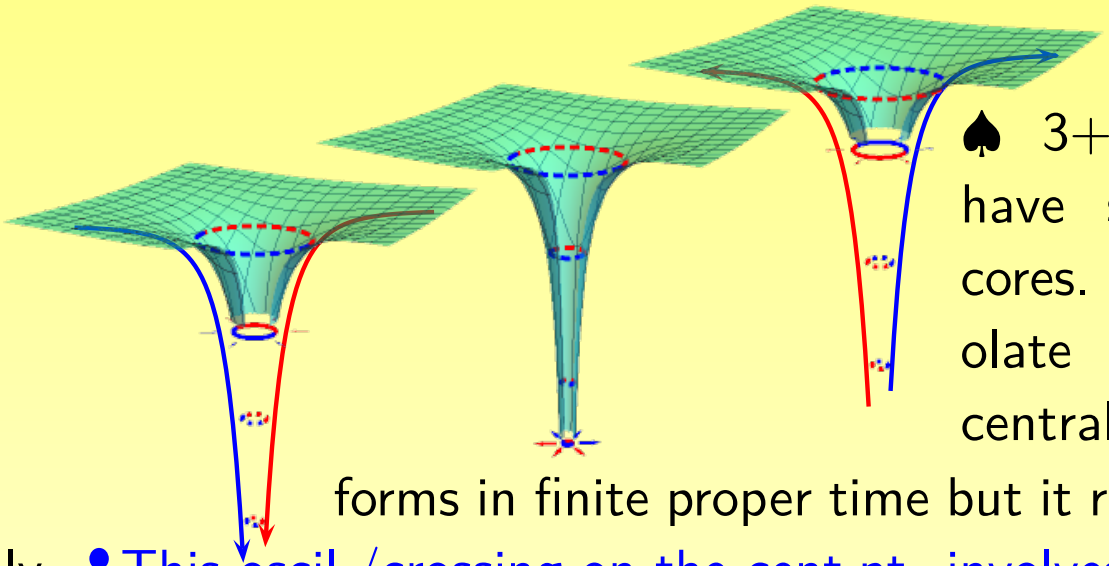

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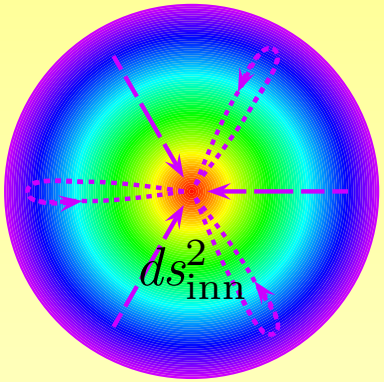
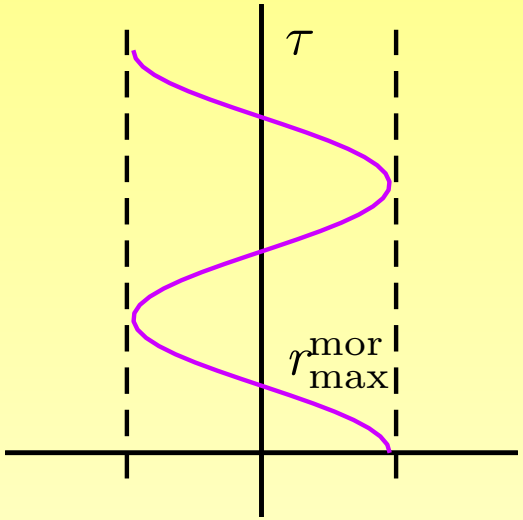
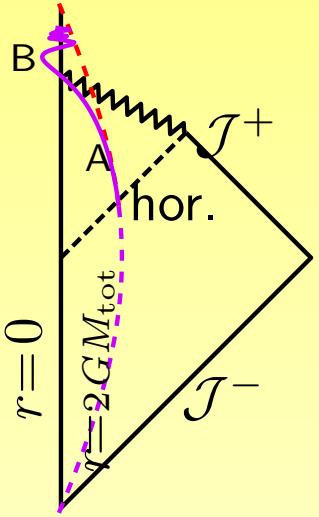
Exact oscillation solutions to the 3+1D dust star

$$ds^2_{\rm out} = -hdt^2 + h^{-1}dr^2 + \cdots$$







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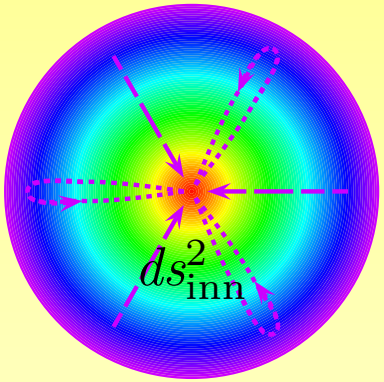

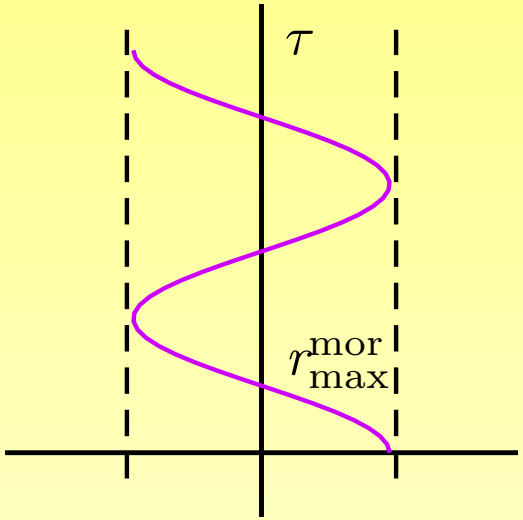

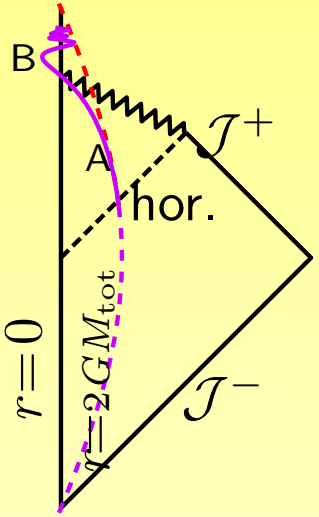

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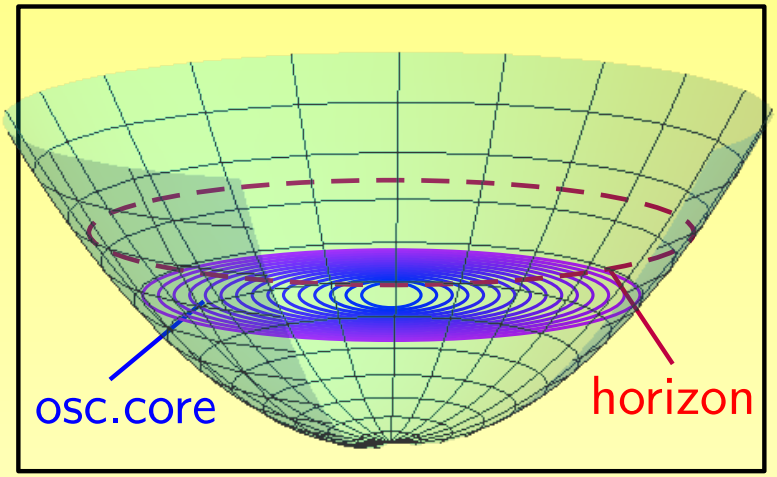
Ev1, the oscillation has $\exp[A/4G]$ eigenmodes



♠ looking the dust contents of AdS2+1 BH as many concentric rings. Due to the triviality of 2+1D GR, these rings have no grav.interaction each other. They only oscillate harmonically in the AdS potential well, each with $E_i = (n_i + \frac{1}{2})\hbar\omega$, $\omega = \ell^{-1}$. ♣ Requiring all E_i add up to $M_{\rm tot}$, the BH microstate counting ⇒ number partition $\sum_i (n_i + \frac{1}{2})\hbar\omega = M$

$$W[M\hbar^{-1}\ell, \{n_i + \frac{1}{2}\}] = \exp\{\frac{A}{4G}(\frac{3\ell}{4G})^{-\frac{1}{2}}\},\ A = 2\pi r_h \qquad (5)$$

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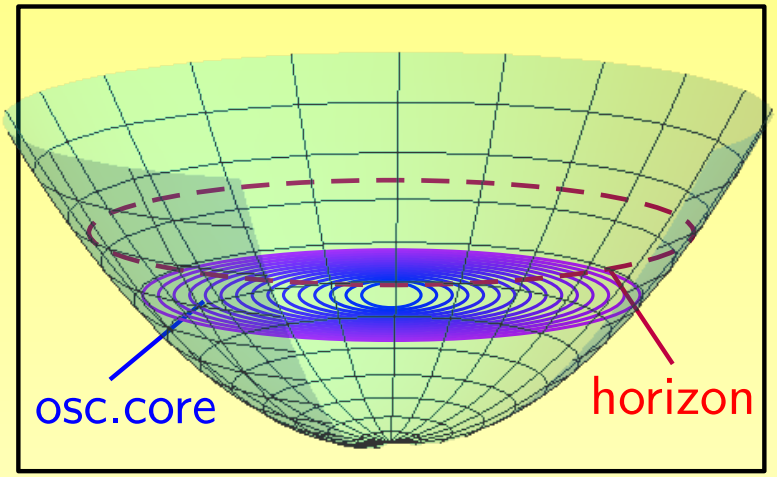

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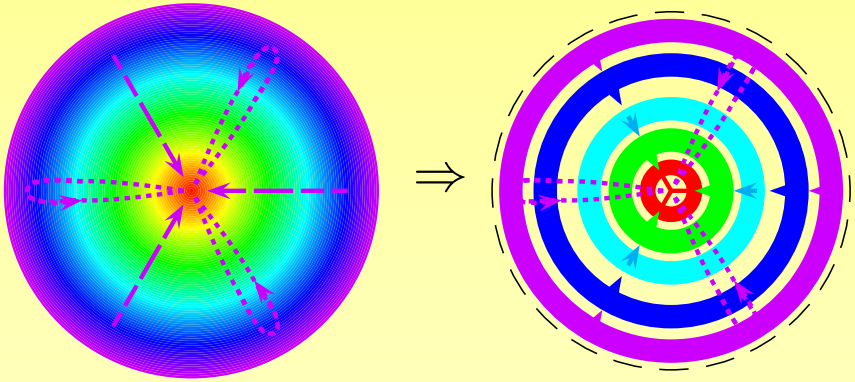
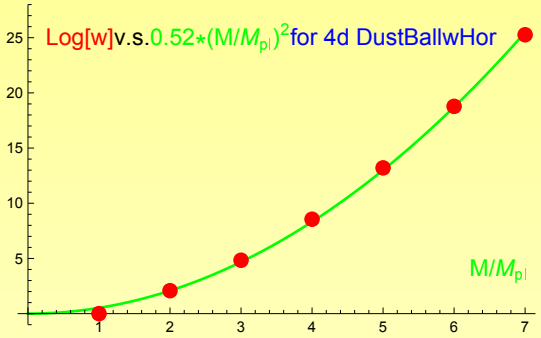
$$\begin{cases} h_i\dot{t}=\gamma \Leftarrow \ddot{x}^0+\Gamma^0_{\mu\nu}\dot{x}^\mu\dot{x}^\nu=0 \\ h_i\dot{t}^2-h_i^{-1}\dot{r}^2=1 \end{cases}, \begin{cases} \dot{r}=\dot{r}, h_i=1-\frac{2GM_i}{r} \\ \dot{t}^2-\dot{r}^2=1 \end{cases} \quad (6)$$





look cont', dynamic m.contents of BH as concentric shells, write w.f. of the system as $\Psi=\Psi_1\otimes\Psi_2\otimes\cdots\Psi_\ell$, $m_i\dot{r}\to\partial_r$

$$[-\hbar^2\partial_r^2-m_i^2(\gamma^2-h^{M_i})]\Psi_i=0,\ \gamma^2\equiv h[r_{\rm rel}]<0 \quad (7)$$

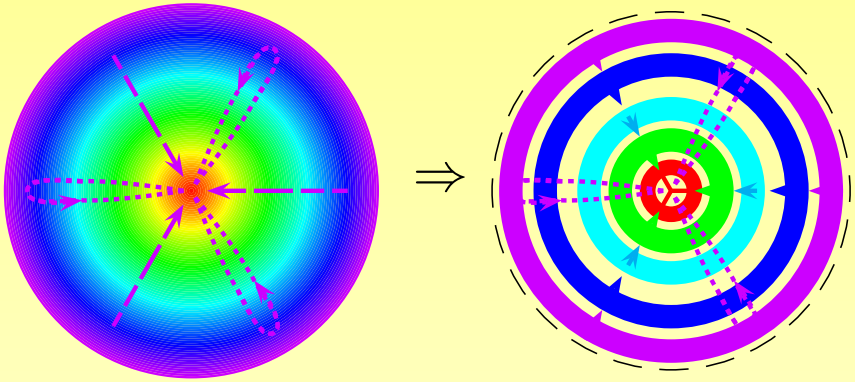
$\frac{GM_im_i\hbar^{-1}}{\sqrt{-\gamma_i^2+1}}=1,2,\cdots,q^i_{\max}\Leftarrow|\Psi_i^2|$ integrable, finite on the origin.

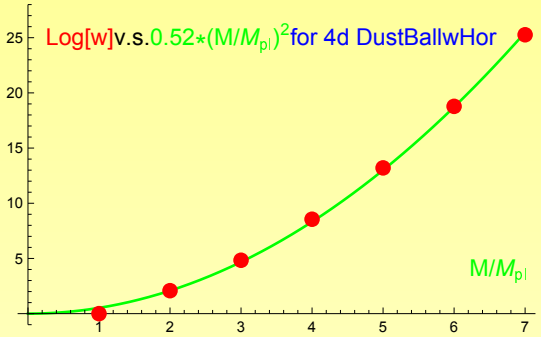
The total # of states

$$w=\sum_m w_m, w_m=\prod_{i=1}^{\ell} q^m_{i\max}, m=\{m_1,m_2\cdots m_\ell\} \quad (8)$$

Ev1(cntd), the oscillation has $\exp[A/4G]$ eigenmodes

$$\begin{cases} h_i\dot{t}=\gamma \Leftarrow \ddot{x}^0+\Gamma^0_{\mu\nu}\dot{x}^\mu\dot{x}^\nu=0 \\ h_i\dot{t}^2-h_i^{-1}\dot{r}^2=1 \end{cases}, \begin{cases} \dot{r}'=\dot{r}, h_i=1-\frac{2GM_i}{r} \\ \dot{t}'^2-\dot{r}'^2=1 \end{cases} \quad (6)$$





look cont', dynamic m.contents of BH as concentric shells, write w.f. of the system as $\Psi=\Psi_1\otimes\Psi_2\otimes\cdots\Psi_\ell$, $m_i\dot{r}\to\partial_r$

$$[-\hbar^2\partial_r^2-m_i^2(\gamma^2-h^{M_i})]\Psi_i=0,\ \gamma^2\equiv h[r_{\rm rel}]<0 \quad (7)$$

$\frac{GM_im_i\hbar^{-1}}{\sqrt{-\gamma_i^2+1}}=1,2,\cdots,q^i_{\max}\Leftarrow|\Psi_i^2|$ integrable, finite on the origin.

The total # of states

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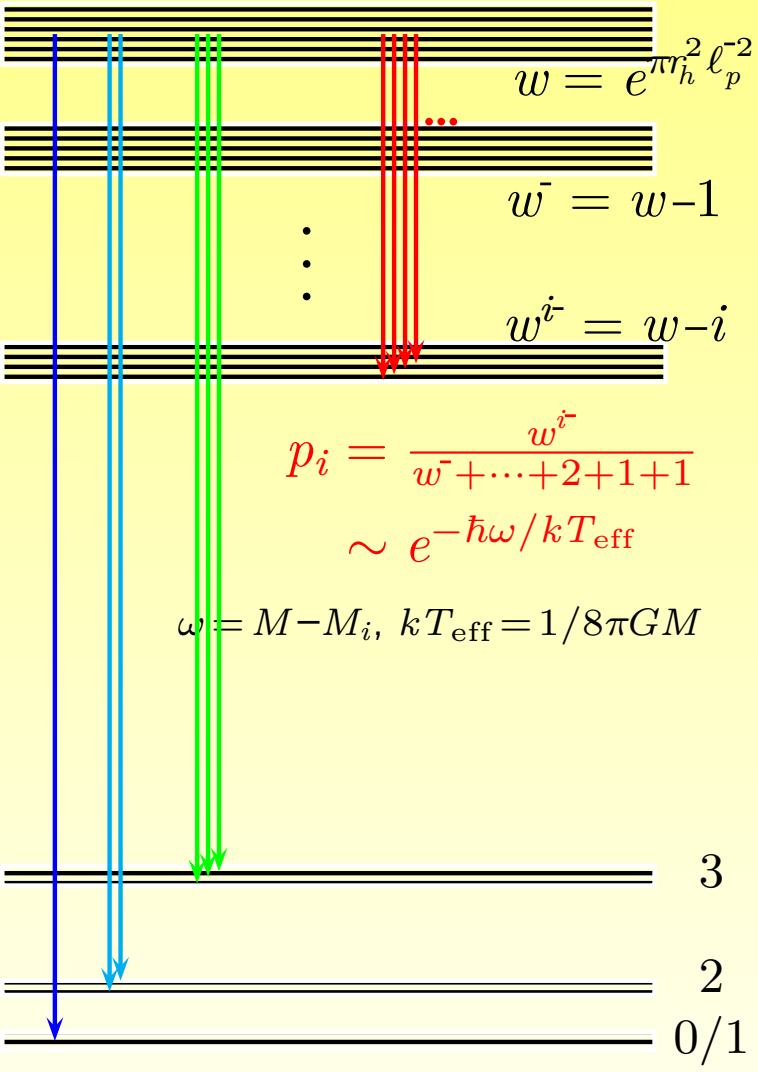
Ev2. Exp[A/4G] inn.modes assure HR. thermofeature



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$$\langle E_{\rm f}\rangle = \frac{\hbar\omega\, e^{-\frac{\hbar\omega}{kT_{\rm eff}}} + 0}{e^{-\frac{\hbar\omega}{kT_{\rm eff}}} + 1} = \frac{\hbar\omega}{e^{\frac{\hbar\omega}{kT_{\rm eff}}} + 1}$$

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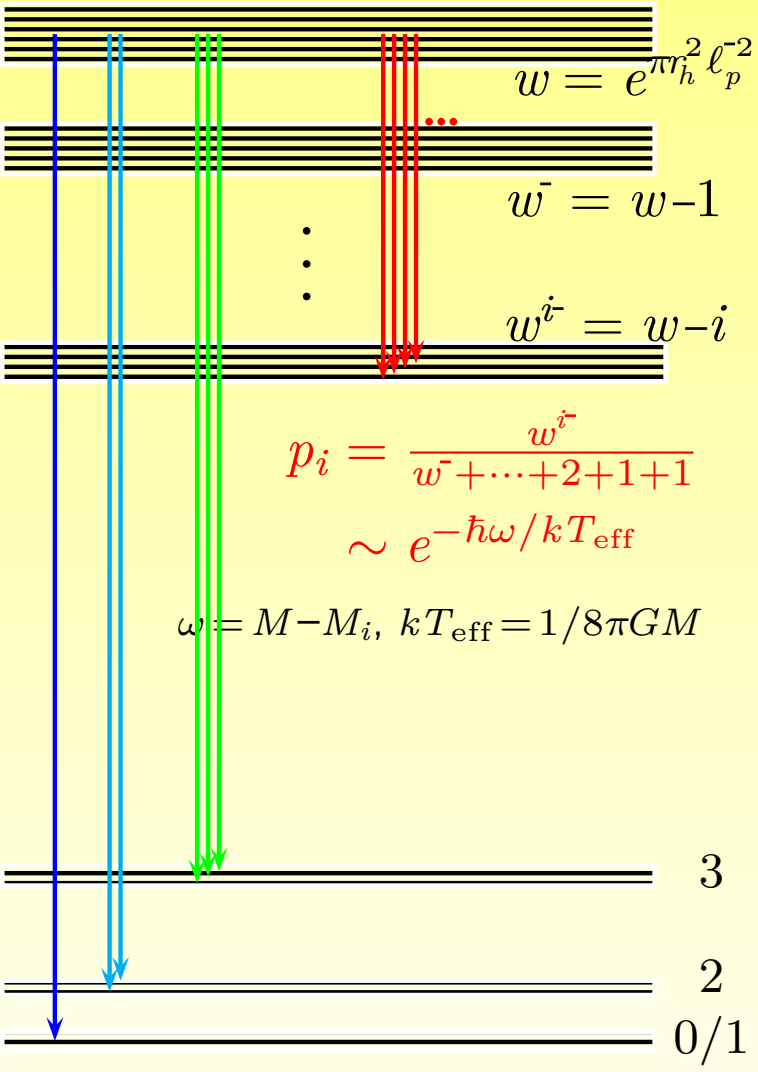

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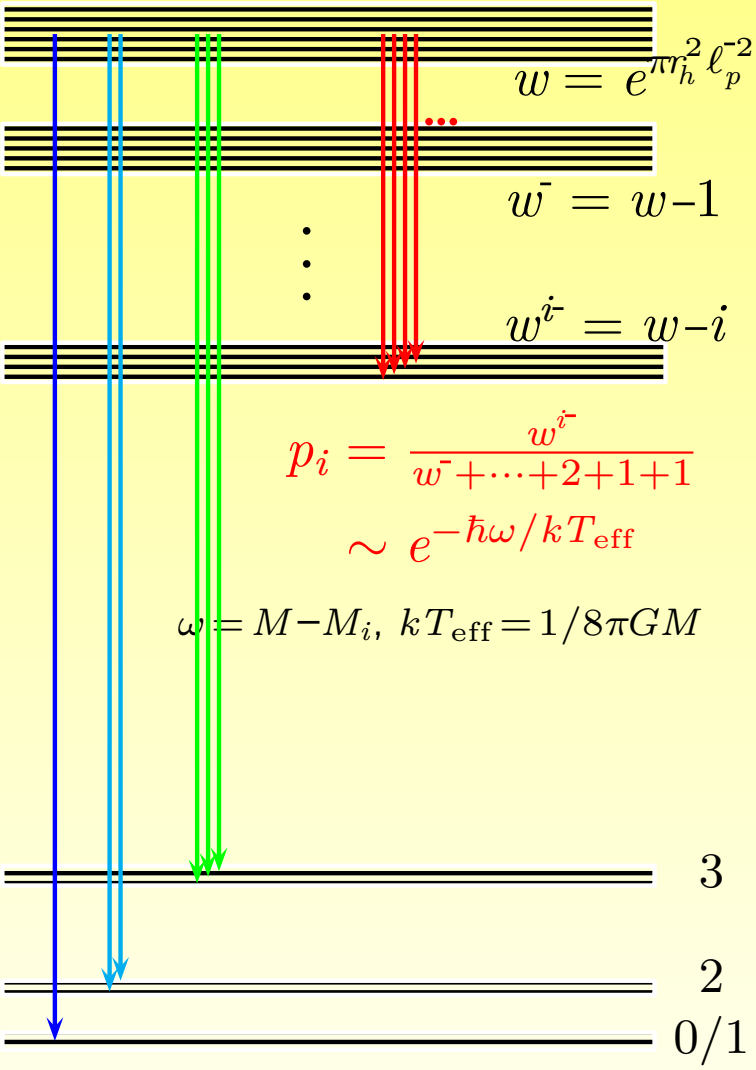

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$$H = H_{\rm BH} + H_{\rm vac} + H_{\rm int} \tag{10}$$

$$= \begin{pmatrix} b_n & & & \\ & b_{n^-} & & \\ & & \ddots & \\ & & & b_0 \end{pmatrix} + \sum_k \hbar\omega_k a_k^\dagger a_k + \sum_{|b_u - b_v|}^{\hbar\omega_k =} g_{uv} b_{uv}^\dagger a_k \tag{11}$$

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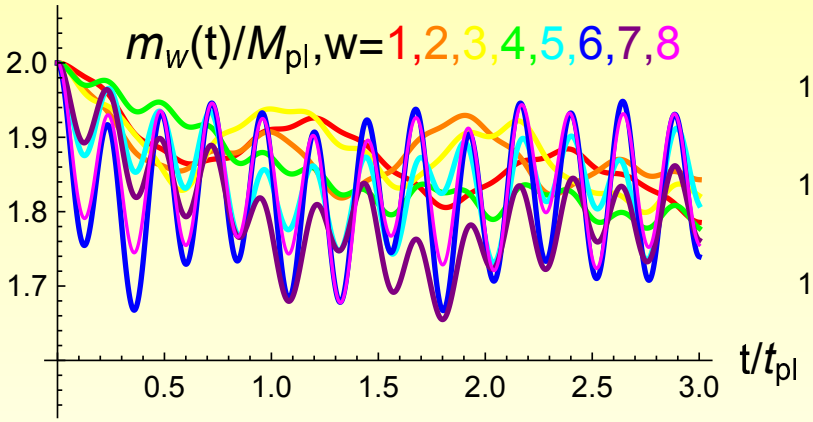
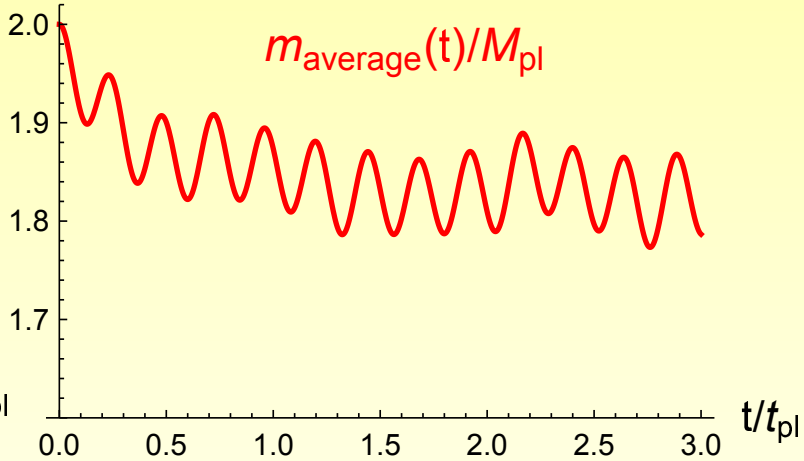
Ex, an 8-microstate BH's evaporation process

setting $|\psi(t)\rangle = \sum_{\ell=0}^{n}\sum_{v=1}^{e^{S_\ell}} e^{-ib_n t} c_{\ell v}(t)|\ell^v, n\text{-}\ell\rangle$, use $i\hbar\partial_t\psi = H\psi$ & $c_{n^w}(0)$–$-1 = c_{n^-}(0)\cdots = 0$, we numerically calc.

$$m_w(t) = \frac{r_h^w(t)}{2G_N} = \sum_{\ell=0}^{n}\sum_{v=1}^{e^{S_\ell}} b_{\ell^v}\, c_{\ell^v}^2(t) \tag{12}$$





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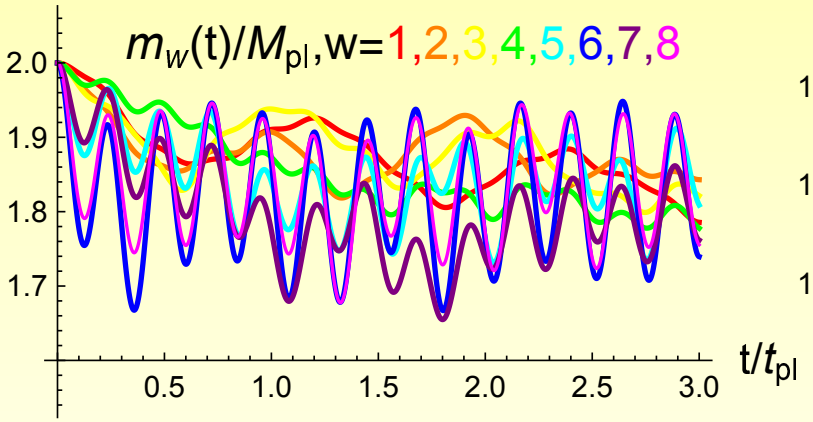

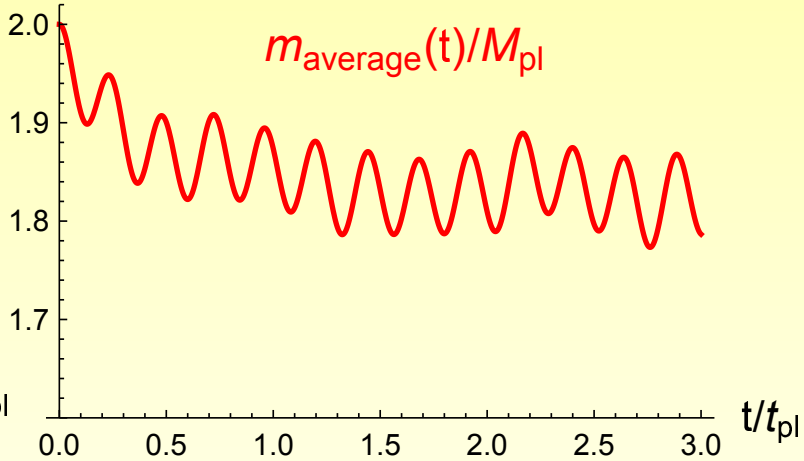

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Measurable inn. struct. violates causility?

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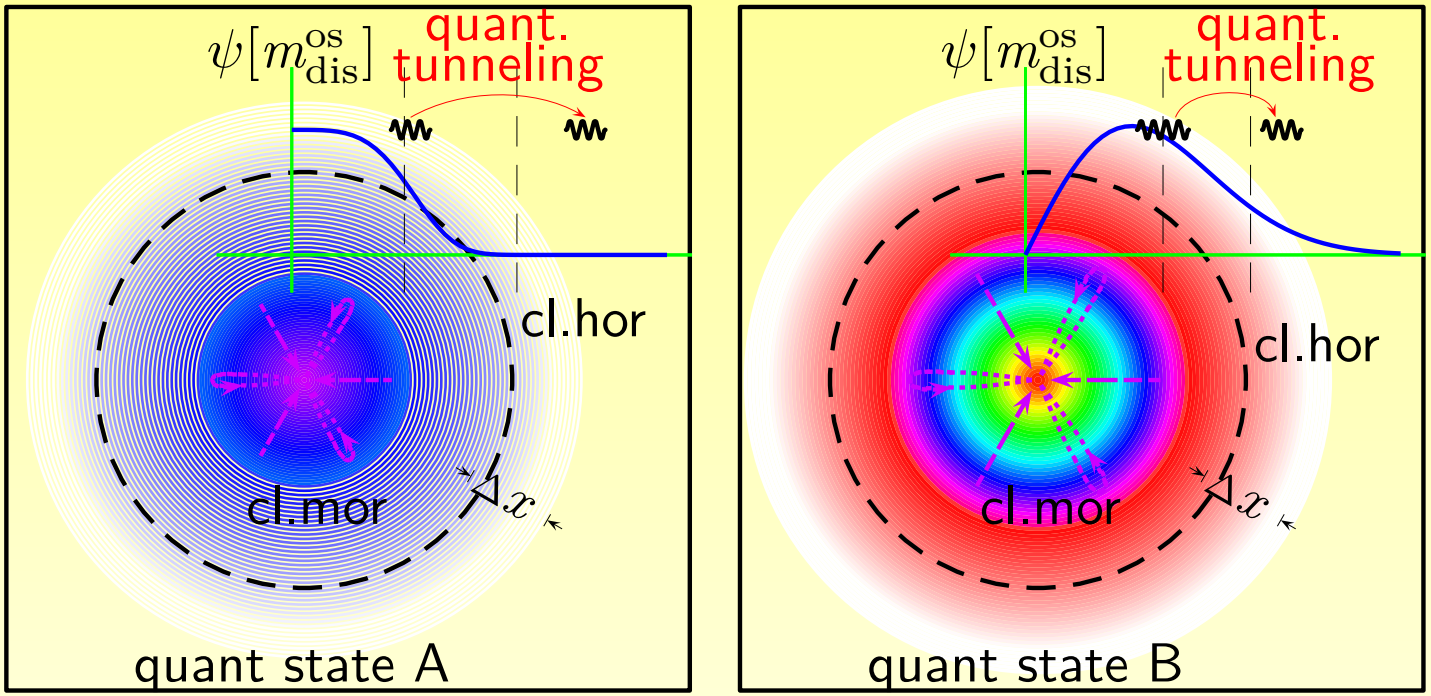

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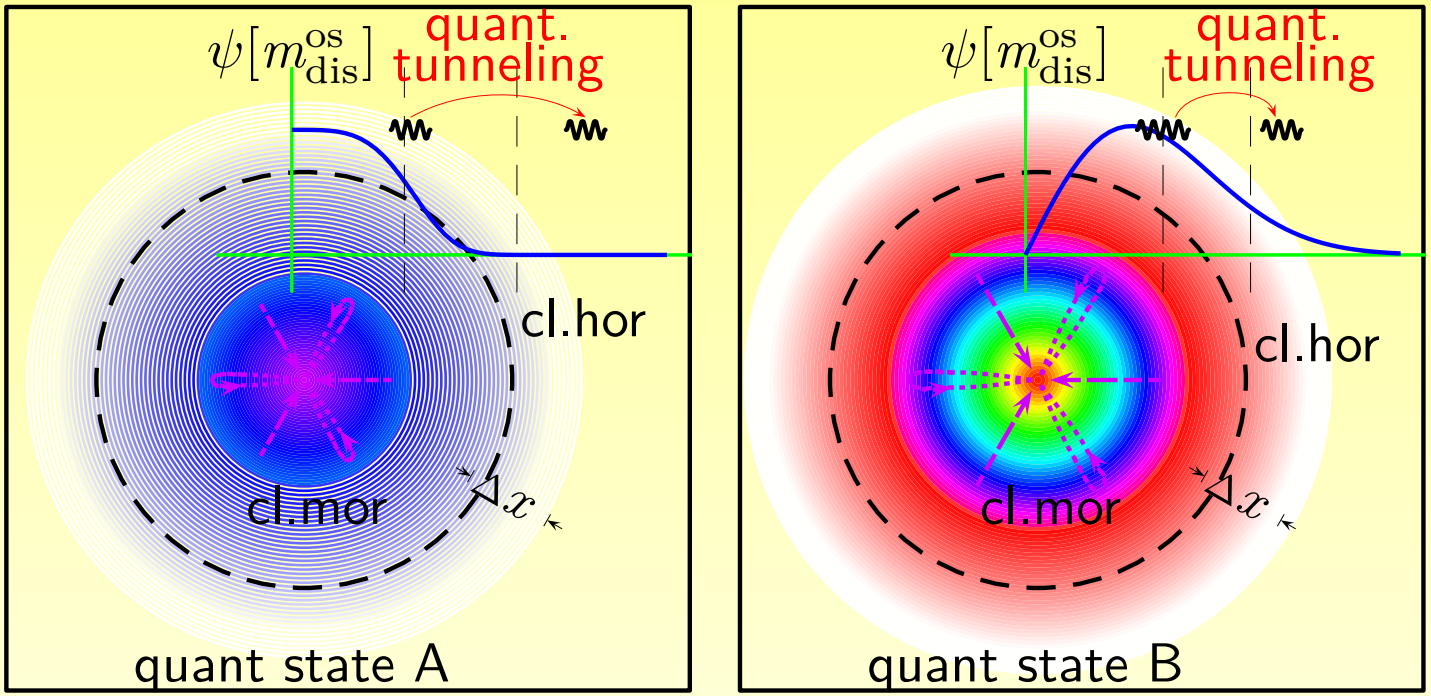

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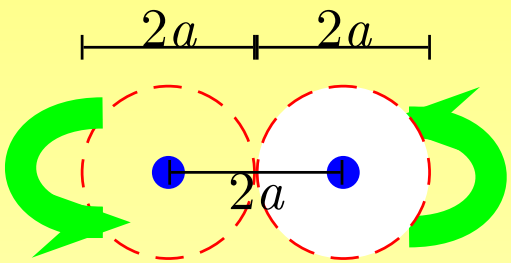

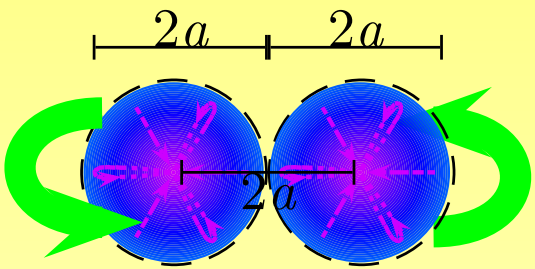

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♠ binary BHs' inspiral and merger. Lf. BHs are just static singularity covered by classic horizons, the quadrupole has only one non-0 component.

♣ Rt. BHs have oscillatory cores, singularity are just periodically appearing, 0-measure phenomena, the system have rather different quadrupoles

♢when they inspiral and radiate GWs, $h_{ij} \propto \ddot{Q}_{ij} \propto D_{ij}$, remarkable diff'. Even the current LIGO/Virgo data may be enough to distinguish which is the case

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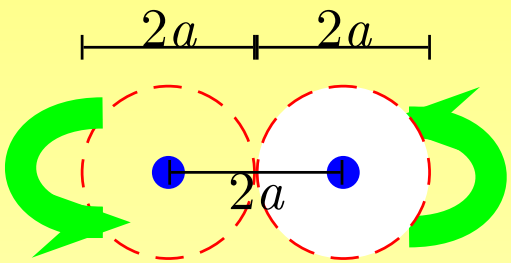

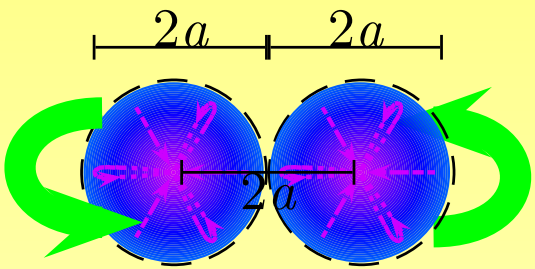

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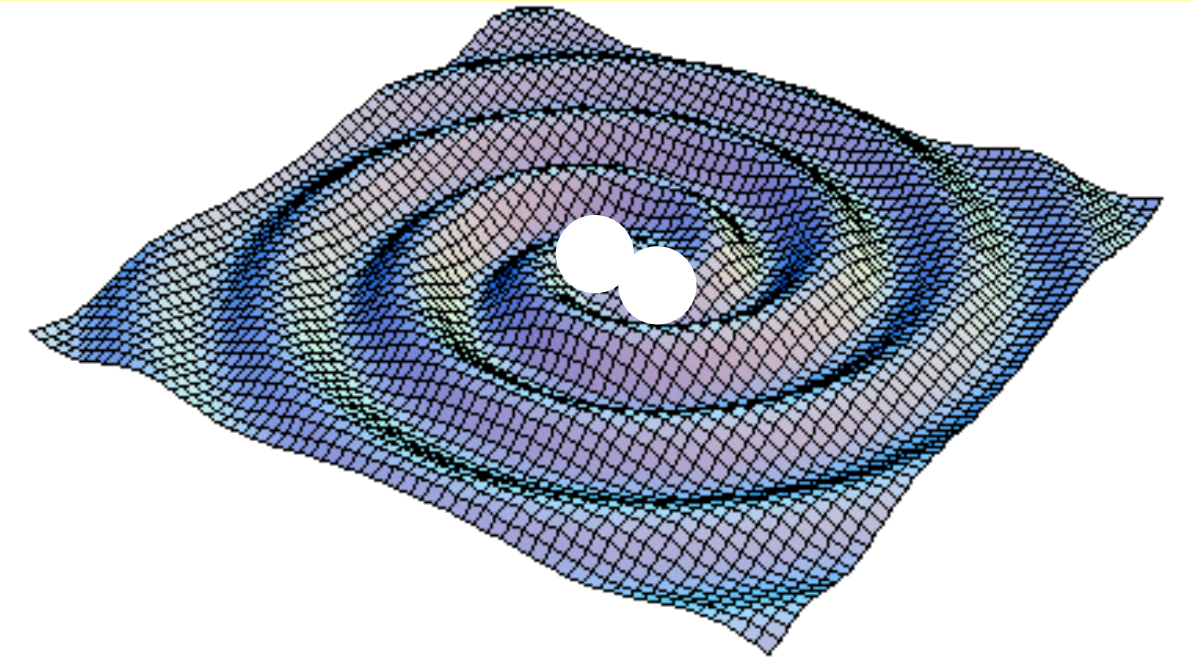

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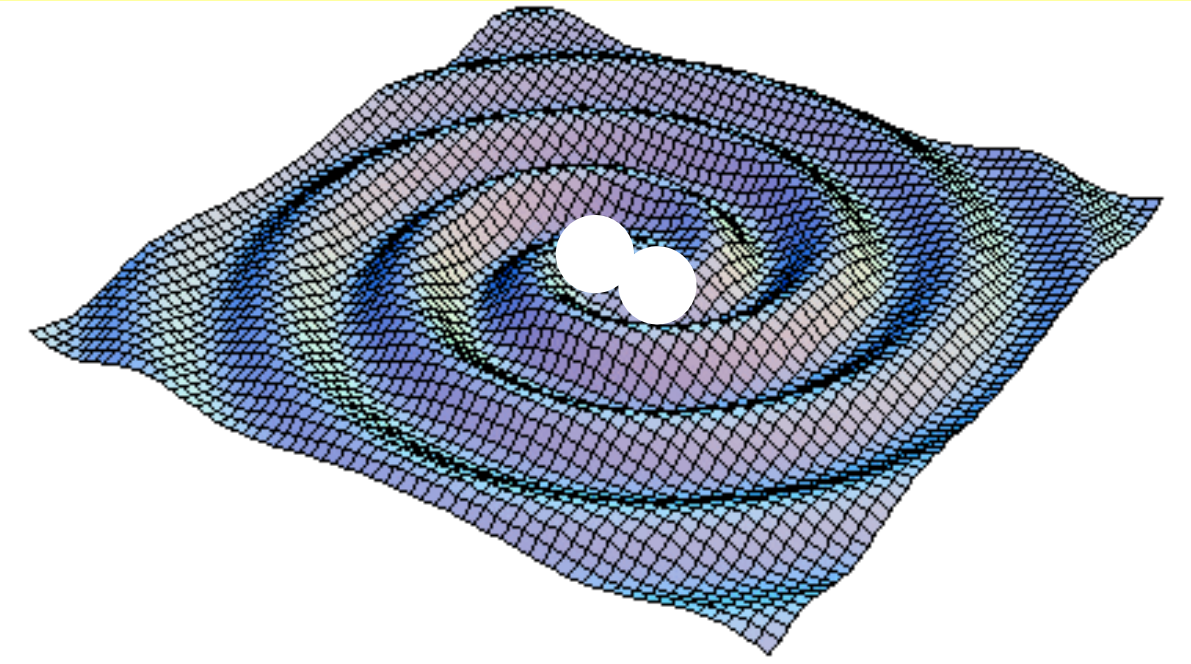

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Summary & discussion

- ♠ BH could have oscillatory matter cores. Hawking probably over-interpreted his singularity theorem.
- ♣ An osci.core has enough eigen-modes to account for the Bekenstein-Hawking entropy
- ♢ Like ordinary atoms, a BH with inn.struct. can spont.R. HR's therm. feature can be attributed to the averaging of this spont.R.
- ♡ Whether BHs have osci.core/not is verifiable through G.W. signals following from bin.BHs' merging
- ▽ More careful analysis of the rel' betw' observational datas and n-Code BCs is needed to answer definitely what inn'struct' the BH has
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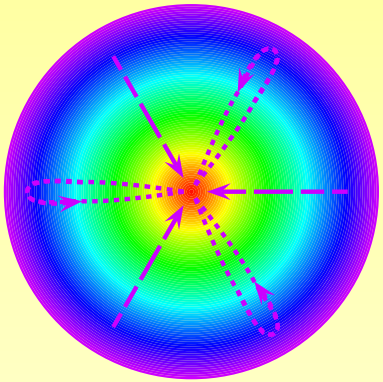
acknowledge

Thank you!

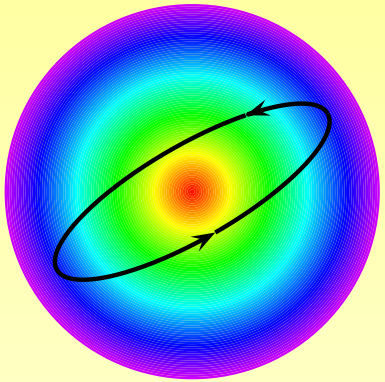
faqs: 1. Why neglect ran'motions contrib' to BH entropy?
2. What's the diff' betwn' our BHs and StrThe fuzzyball?
3. Who can see oscillations inside the BH?

Why neglect random motions' contrib' to BH entropy

♠ The number of such dof. $\propto N$(particle no.) $\propto M$(BH mass) $\propto r_H$(horizon size), while $S_{\rm BH} \propto A_{rea} \propto r_h^2$. So the rand.mo' dof is non-enough.



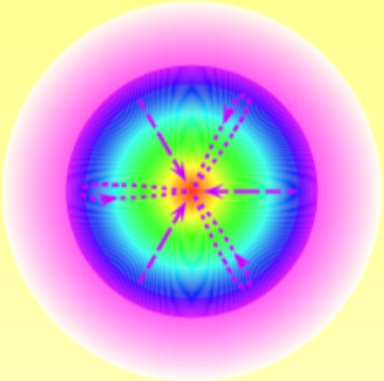
♣ in a BH (s.symm) without static singular central, all radial motion ~ 0 Angular Momentum, while all non-radial motion have non-0 AM. The non-0 AM

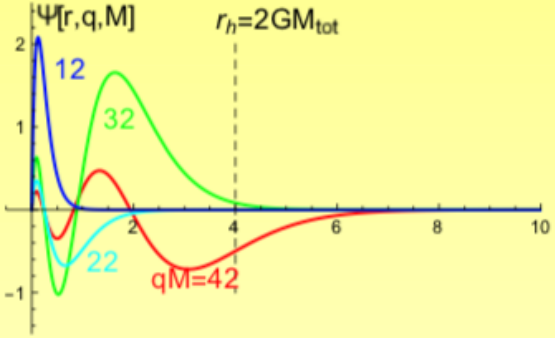


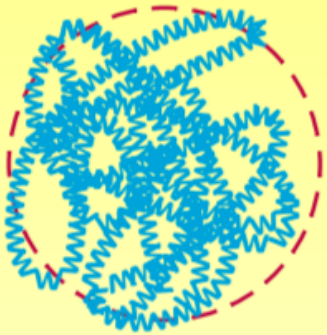
particle will not hit on the central point in any finite time. This contradicts with the ST which says that ...

♢ Modes (#1) of the radial oscillation is not part of the random motion (#2) of particles consisting of the BH, they are collective modes of their motion. #2<#1

Is our blurred horizon BH diff' from StrThe fuzzyballs?







♣ StrThe fuzzball depends on hyperphysic concepts such as extra-dimension, SUSY etal, and has no implementation for macroscopic BHs

♠ Our blurred horizon follows from the quantum description of matters consisting of BHs, whose classic behavior is controlled by GR simply.

♢ Logically, we should require all reasonable QG to give pictures of BH like ours, instead of arguing our picture's rationality using QG trying such as StrThe

Who can see oscillations inside the BH

♠ Due to exis. the horizon, external observer cannot see such oscillations. However, observers sitting on the central point of a collapsing star can.

♣ Microstate of grav.sys., the observer and observables have different time def.

Other.sys., the same time def.