Information Missing Puzzle, Where Is Hawking’s Error?
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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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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.

Ex., AdS2+1 dust stars, (OI)

ST, static conical singularity is the final. However, Eins.Eq

\[ ds^2_{\text{inn}} = -d\tau^2 + a^2 \left[ \frac{d\varrho^2}{\kappa} + \varrho^2 d\phi^2 \right] \] (1)

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

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\[ M(\varrho)_{\text{max}} = M_{\text{tot}}, \quad M(\varrho) \quad \text{expr'} \]

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♠ Just like ordinary atoms, BHs with oscillatory core will spontaneously radiate, indistinguishable 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

\[ S = 1 + iT \]  

(2)

♦ It is the fwd. scatt. ampl. that turns the eternally static, central singularity into a passers-by, zero-measure one.
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Exact oscillation solutions to the 3+1D dust star

\[ ds_{\text{out}}^2 = -h dt^2 + h^{-1} dr^2 + \cdots \]

\[ ds_{\text{inn}}^2 = -d\tau^2 + \frac{1 - \left( \frac{2GM}{\varrho^3} \right)^{\frac{1}{2}} \frac{M'}{2M} \tau}{a[t, \varrho]}^2 d\varrho^2 + a[\tau, \varrho]^2 \varrho^2 d\Omega_2^2 \quad (3) \]

\[ a[\tau, \varrho] = \left[ 1 - \frac{3}{2} \left( \frac{2GM[\varrho]}{\varrho^3} \right)^{\frac{1}{2}} \tau \right]^{\frac{2}{3}}, \quad M[\varrho_{\text{hor}} \leq \varrho] = M_{\text{tot}} \quad (4) \]

\[ \text{on the boundary (dynamic, } r = r_{\text{mor max}}^{\text{mor max}}) \text{ of matter occupation region, } g_{\mu \nu}^{\text{out}} \xrightarrow{\text{co.trans}} g_{\mu \nu}^{\text{inn}} \text{ smoothly, } M[\rho] \text{ function's multiple possibility } \sim \text{ the microstate's multiplicity} \]
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♠ on the boundary (dynamic, \( r = r_{\text{mor max}} \)) of matter occupation region, \( g^{\text{out}}_{\mu\nu} \xrightarrow{\text{co.trans}} g^{\text{inn}}_{\mu\nu} \) smoothly, \( M[\rho] \) function’s multiple possibility ~ the microstate’s multiplicity
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 \( M_{\text{tot}} \), the BH microstate counting ⇒ number partition

\[
\sum_i (n_i + \frac{1}{2})\hbar\omega = M
\]

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

Except for a pure number factor \( \left( \frac{3\ell}{4G} \right)^{-\frac{1}{2}} \), \( \log W \) happens to be the Bekenstein-Hawking entropy formula

- For 3+1 Schwz BHs, similar results, but more complicated maths and physics [NPB930.533, 941.665].
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 $M_{tot}$, the BH microstate counting ⇒ number partition

$$\sum_i (n_i + \frac{1}{2})\hbar\omega = M$$

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Except for a pure number factor $\left(\frac{3\ell}{4G}\right)^{-\frac{1}{2}}$, log $W$ happens to be the Bekenstein-Hawking entropy formula.

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

\[
\begin{align*}
\begin{cases}
    h_i \dot{t} &= \gamma \Leftrightarrow \dot{x}^0 + \Gamma^0_{\mu\nu} \dot{x}^\mu \dot{x}^\nu = 0, \\
    h_i \dot{t}^2 - h_i^{-1} \dot{r}^2 &= 1
\end{cases}
\end{align*}
\]

\[i^2 - r^2 = 1 \quad (6)\]

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

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

\[
\frac{GM_i m_i \hbar^{-1}}{\sqrt{-\gamma_i^2 + 1}} = 1, 2, \cdots, q_{i_{\text{max}}}^i \Leftrightarrow |\Psi_i^2| \text{ integrable, finite on the origin.}
\]

The total # of states

\[
w = \sum_m w_m, \quad w_m = \prod_{i=1}^{\ell} q_{i_{\text{max}}}^m, \quad m = \{m_1, m_2, \cdots, m_{\ell}\}
\]  (8)
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$$\begin{cases} h_i \dot{t} = \gamma \left< \ddot{x}^0 + \Gamma^0_{\mu \nu} \dot{x}^\mu \dot{x}^\nu \right> = 0 \\
h_i \dot{r}^2 - h_i^{-1} \dot{r}^2 = 1 \end{cases} \quad \Rightarrow \quad \begin{cases} \dot{r} = \dot{r}, \quad h_i = 1 - \frac{2GM_i}{r} \\
\dot{r}^2 - r^2 = 1 \end{cases} \quad (6)$$

$$\begin{matrix}
\text{Log}[w] \text{v.s.} 0.52 \ast (\text{M/M}_p)^2 \text{ for 4d DustBallwHor} \\
\text{M/M}_p
\end{matrix}$$

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

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

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

\[ w = e^{\pi \hbar^2 \ell_p^2} \]

\[ w^r = w - 1 \]

\[ w^i = w - i \]

\[ p_i = \frac{w^r}{w + \cdots + 2 + 1 + 1} \sim e^{-\hbar \omega / kT_{\text{eff}}} \]

\[ \omega = M - M_i, \quad kT_{\text{eff}} = 1/8\pi GM \]

\[ \langle E_f \rangle = \frac{\hbar \omega e^{-\hbar \omega / kT_{\text{eff}}} + 0}{e^{-\hbar \omega / kT_{\text{eff}}} + 1} = \frac{\hbar \omega}{e^{kT_{\text{eff}}} + 1} \]

\[ \langle E_b \rangle = \frac{\sum_n n \hbar \omega e^{-n\hbar \omega / kT_{\text{eff}}}}{\sum_n e^{-n\hbar \omega / kT_{\text{eff}}}} = \frac{\hbar \omega}{e^{kT_{\text{eff}}} - 1} \]

\[ \text{This is a pure statistic deriv.} \]

The resultant therm. spectrum implies no IMP at all
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Grav. mono ind. spont. R (i) both ini&finl state have the same symmetry (ii) all possible finl state allowed by symm. can be reached

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\[ \sum_n e^{-n\hbar \omega/kT_{\text{eff}}} (9) \]

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The resultant therm. spec-trum implies no IMP at all
Ev2 (cntd). HR as spont. R of BH with inn struct.

♠ For BHs with inner structure, HR can be looked as their Spont. R, has hamiltonian thus explicitly unitary formul’ [NPB941.665]

\[ H = H_{BH} + H_{vac} + H_{int} \]  

\[ = \left( \begin{array}{ccc} b_n & b_n^- & \ldots \\ \vdots & \vdots & \ddots \\ b_0 & & & \end{array} \right) \nonumber \]

\[ + \sum_k \hbar \omega_k a_k^\dagger a_k + \sum |b_u - b_v| g_{uv} b_{uv}^\dagger a_k \]  

\[ e^{\pi b_n^2/G} \text{-times degenerated, } a_k^\dagger a_k \sim \text{fluct. modes in vac.} \]

\[ b_{uv}^\dagger a_k \text{ reduce BH from } b_v \text{ to } b_u \text{ by realizing a vac. mode } k \text{ or vice versa.} \]

♣ When evaporating, each microstate BH has its own characteristic horizon-size v.s. time line \( r_h(t) \), measurable and can be used as initial state reconstruction basis.
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$$= \begin{pmatrix} b_n & b_n^- & \ldots & b_0 \end{pmatrix} + \sum_{k} \hbar \omega_{k} a_{k}^{\dagger} a_{k} + \sum_{|b_u - b_v|} g_{uv} b_{uv}^{\dagger} a_{k}$$  \hspace{1cm} (11)

$b_n$, $e^{\pi b_n^2/G}$-times degenerated, $a_{k}^{\dagger} a_{k} \sim$ fluct. modes in vac. $b_{uv}^{\dagger} a_{k}$ reduce BH from $b_{v}$ to $b_{u}$ by realizing a vac. mode $k$ or vice versa.

When evaporating, each microstate BH has its own characteristic horizon-size v.s. time line $r_{h}(t)$, measurable and can be used as initial state reconstruction basis.
Each microstate BH has its own characteristic evaporation curve $m_w(t)$, the non-monotone feature follows from our assumption of s.symm. of the ini & fnl state.
Ex, an 8-microstate BH’s evaporation process

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

\[
m_{w}(t) = \frac{r_{h}^{w}(t)}{2G_{N}} = \sum_{\ell=0}^{n} \sum_{v=1}^{e^{S_{\ell}}} b_{\ell v} c_{\ell v}^{2}(t) \quad (12)
\]

Each microstate BH has its own characteristic evaporation curve \(m_{w}(t)\), the non-monotone feature follows from our assumption of s.symm. of the ini & fnl state
Measurable inn. struct. violates causality?

✿ No, at quantum levels, the horizon is blurred. We have no cut-clear horizons [NPB941,665] at all

HR occurs thru. quant. tunneling, its more easy implementation in B is intuitive

\[ \Delta x = \Delta r^{\text{shell\ outmost}} \approx r_h, \text{ surprising!} \]  \hspace{1cm} (13)
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∆x

ψ[m^{os}_{dis}] tunnelling

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cl.hor

cl.hor

cl.mor

cl.mor

quant state A

quant state B

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Δx = Δr^{shell}_{outmost} ≈ r_h, surprising! (13)
Osci’ or StatSinglarity is disprovable observationaly

\[ a = 2GM, \quad D_{xx} = 2Ma^2 \]
\[ D_{ij} = 0, \quad ij \neq xx \]

\[ a = 2GM, \quad D_{xx} = \frac{12}{5}Ma^2 \]
\[ D_{yy} = D_{zz} = \frac{2}{5}Ma^2, \quad D_{ij} = 0, \quad i \neq j \]

♠️ 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, \( h_{ij} \propto \dot{Q}_{ij} \propto D_{ij} \), remarkable diff’. Even the current LIGO/Virgo data may be enough to distinguish which is the case.
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♠ 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
Will our Q-pole and GW strength contradict LIGO?

♠ No, in the current observ’. The BH is not assumed as a simple singular mass point wrapped by a horizon. The inner horizon region is excised from the numeric code.

♣ The inner horizon matter distr’/motion modes are encoded in some boundary conditions. The relation between the relevant BC and BH inner structures is not considered carefully yet
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♠ 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

▲ The idea of allowing matters to go across each other on the Central of BHs has interesting implications for the early universe
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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. \( \propto N(\text{particle no.}) \propto M(\text{BH mass}) \propto r_H(\text{horizon size}) \), while \( S_{\text{BH}} \propto A_{\text{rea}} \propto r_h^2 \). So the rand.mo’ dof is non-enough.

♠ in a BH (s.symm) without static singular central, all radial motion \( \sim 0 \) 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.