

XOB Reveals Physics Inside Black Holes

Dingfang Zeng, Beijing University of Technology

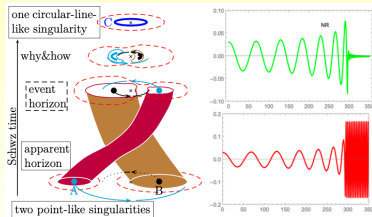
ref: 2505.14749(in updating), 2505.14750(in updating), EPJC84(2024)

The Second New Horizons for Psi Workshop , Aug 24, 2026

The GW of BHB merger process damps at late time. This is well known but hardly understandable if BHs are singular as is widely believed. Because two point-like singularities can not become a circular-line-like one simply through in-spiral and radiation.

XOB (eXact One-Body method) provides evidence that this arises from the no-horizon non-singular structure of BHs involved in this process, for which NR's description is only an equivalent one

Do you understand my question?



Is the damping GW possible for BHs with central singularity

- NR cannot answer this question because its BHs are defined by Apparent-Horizons rather than Event-Horizon & singularity.

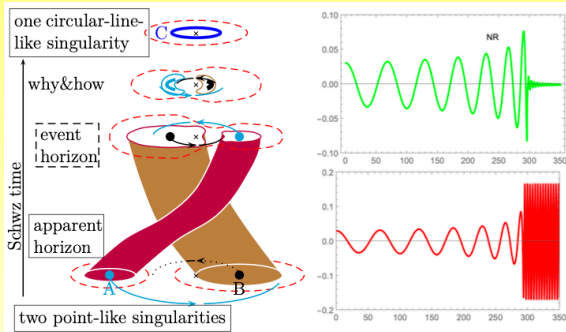
- AH lies inside EH, its shape and motion is strongly correlated with the GW-form far away. Such correlation propagates at the speed of light

- BHs in NR has no EH at all, what it tells us is the dynamics of gravitation and a surface inside the EH

- BHPT cannot answer this question either, because its dissipation happens on BH backgrounds with rotational symmetry already. It says nothing on the symmetry transition of the system at all.

♣ Is there singularity inside BHs simulated in NR and observed in AstrObsv? XOB argues this is a fundamental question to be resolved and resolvable in GR

♠ It resolves this question through a transparent computation of the GWforms of binary merger process



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

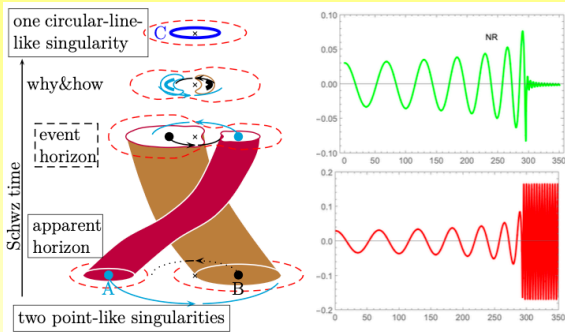
Is the damping GW possible for BHs with central singularity

- NR cannot answer this question because its BHs are defined by Apparent-Horizons rather than Event-Horizon & singularity.

- AH lies inside EH, its shape and motion is strongly correlated with the GW-form far away. Such correlation propagates at the speed of light

- BHs in NR has no EH at all, what it tells us is the dynamics of gravitation and a surface inside the EH

- BHPT cannot answer this question either, because its dissipation happens on BH backgrounds with rotational symmetry already. It says nothing on the symmetry transition of the system at all.



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

♣ Is there singularity inside BHs simulated in NR and observed in AstrObsv? XOB argues this is a fundamental question to be resolved and resolvable in GR

♠ It resolves this question through a transparent computation of the GWforms of binary merger process

Is the damping GW possible for BHs with central singularity

- NR cannot answer this question because its BHs are defined by Apparent-Horizons rather than Event-Horizon & singularity.

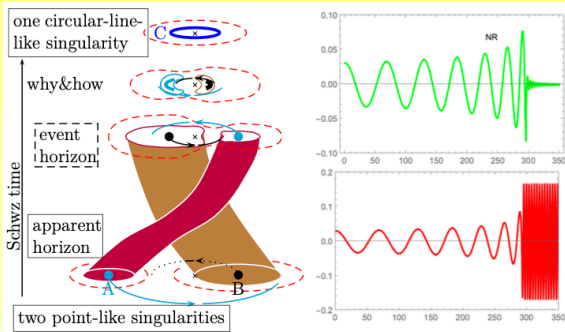
- AH lies inside EH, its shape and motion is strongly correlated with the GW-form far away. Such correlation propagates at the speed of light

- BHs in NR has no EH at all, what it tells us is the dynamics of gravitation and a surface inside the EH

- BHPT cannot answer this question either, because its dissipation happens on BH backgrounds with rotational symmetry already. It says nothing on the symmetry transition of the system at all.

♣ Is there singularity inside BHs simulated in NR and observed in AstrObsv? XOB argues this is a fundamental question to be resolved and resolvable in GR

♠ It resolves this question through a transparent computation of the GWforms of binary merger process



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

Is the damping GW possible for BHs with central singularity

- NR cannot answer this question because its BHs are defined by Apparent-Horizons rather than Event-Horizon & singularity.

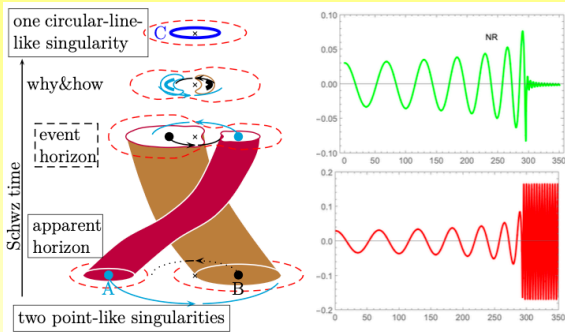
- AH lies inside EH, its shape and motion is strongly correlated with the GW-form far away. Such correlation propagates at the speed of light

- BHs in NR has no EH at all, what it tells us is the dynamics of gravitation and a surface inside the EH

- BHPT cannot answer this question either, because its dissipation happens on BH backgrounds with rotational symmetry already. It says nothing on the symmetry transition of the system at all.

♣ Is there singularity inside BHs simulated in NR and observed in AstrObsv? XOB argues this is a fundamental question to be resolved and resolvable in GR

♠ It resolves this question through a transparent computation of the GWforms of binary merger process



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

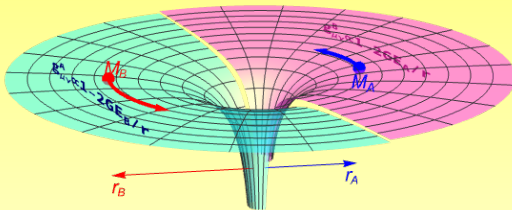
Conclusion

Appendix

XOB approach to the conservative part of GR binary dynamics

the full binary dynamics of GR cannot be one-bodylized because GR does not use concepts like force and acceleration to describe motions

XOB utilises a patchworked geometry to account for the interaction between the two merger participants.



$$ds_A^2 = -h_A dt^2 + h_A^{-1} dr^2 + x_A^2 \cdot \theta + r^2 d\phi^2, \quad (1a)$$

$$ds_B^2 = -h_B dt^2 + h_B^{-1} dr^2 + x_B^2 \cdot \theta + r^2 d\phi^2, \quad (1b)$$

$$h_A = 1 - \frac{2GE_A}{r}, h_B = 1 - \frac{2GE_B}{r}, \quad (1c)$$

Each patch hosts a merger participant and rotates synchronously with it. The separation between the two bodies and their inspiral frequency will be determined by the flux balance condition at infinities when the GW radiation is considered. $\theta \sim d\theta_{\theta \equiv \pi/2}^2$. Metric(1) satisfies vacuum Einstein equation but the two patches are not joined smoothly.



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

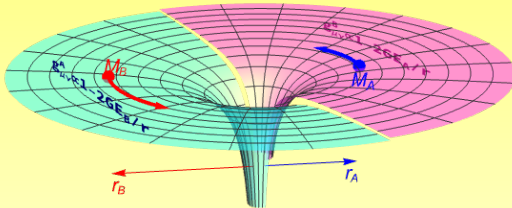
Conclusion

Appendix

XOB approach to the conservative part of GR binary dynamics

the full binary dynamics of GR cannot be one-bodylized because GR does not use concepts like force and acceleration to describe motions

XOB utilises a patchworked geometry to account for the interaction between the two merger participants.



$$ds_A^2 = -h_A dt^2 + h_A^{-1} dr^2 + x_A^2 \cdot \theta + r^2 d\phi^2, \quad (1a)$$

$$ds_B^2 = -h_B dt^2 + h_B^{-1} dr^2 + x_B^2 \cdot \theta + r^2 d\phi^2, \quad (1b)$$

$$h_A = 1 - \frac{2GE_A}{r}, \quad h_B = 1 - \frac{2GE_B}{r}, \quad (1c)$$

Each patch hosts a merger participant and rotates synchronously with it. The separation between the two bodies and their inspiral frequency will be determined by the flux balance condition at infinities when the GW radiation is considered. $\theta \sim d\theta_{\theta \equiv \pi/2}^2$. Metric(1) satisfies vacuum Einstein equation but the two patches are not joined smoothly.



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

XOB hamiltonian and its equivalence with PN-expansion

The lagrangian of the two particles in the patch-worked geometry reads

$$L = -M_A \sqrt{-g_{\mu\nu}^A \dot{x}_A^\mu \dot{x}_A^\nu} - M_B \sqrt{-g_{\mu\nu}^B \dot{x}_B^\mu \dot{x}_B^\nu} + L_{\text{dissipation}} \quad (2)$$

$$g_{\mu\nu}^A \dot{x}_A^\mu \dot{x}_A^\nu = -h_B + h_B^{-1} \dot{a}_A^2 + \dot{\phi}_A^2 a_A^2, g_{\mu\nu}^B \dot{x}_B^\mu \dot{x}_B^\nu \text{ similar}$$

requiring the central of the patch-worked geometry be fixed and the two patches' inspiral be synchronous leads to

$$a_A = \frac{M_B a}{M}, a_B = \frac{M_A a}{M}, E_A = \frac{M_B^3}{M^2}, E_B = \frac{M_A^3}{M^2} \quad (3)$$

This translates the conservative part of the binary problem (2) into a single body one

$$H = \frac{M_A \sqrt{1 - \frac{4GM_B^2}{aM(1-e^2)} + \frac{4G^2 M_B^4}{a^2 M^2 (1-e^2)}}}{\sqrt{1 - \frac{(3+e^2)GM_B^2}{aM(1-e^2)}}} + \left(\begin{matrix} A \\ \updownarrow \\ B \end{matrix} \right), J = \frac{GM_A M_B a (1 - e^2)}{M \sqrt{\frac{aM(1-e^2)}{GM_B^2}} \sqrt{1 - \frac{(3+e^2)GM_B^2}{aM(1-e^2)}}} \left(\begin{matrix} A \\ \updownarrow \\ B \end{matrix} \right). \quad (4)$$

The low-speed-weak-field expansion of (4) matches with the PN-series of GR at any given order n , up to some functions of lower order conservative E_{n-1} and J_{n-1} .

eXact is just in this sense



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

XOB hamiltonian and its equivalence with PN-expansion

The lagrangian of the two particles in the patch-worked geometry reads

$$L = -M_A \sqrt{-g_{\mu\nu}^A \dot{x}_A^\mu \dot{x}_A^\nu} - M_B \sqrt{-g_{\mu\nu}^B \dot{x}_B^\mu \dot{x}_B^\nu} + L_{\text{dissipation}} \quad (2)$$

$$g_{\mu\nu}^A \dot{x}_A^\mu \dot{x}_A^\nu = -h_B + h_B^{-1} \dot{a}_A^2 + \dot{\phi}_A^2 a_A^2, g_{\mu\nu}^B \dot{x}_B^\mu \dot{x}_B^\nu \text{ similar}$$

requiring the central of the patch-worked geometry be fixed and the two patches' inspiral be synchronous leads to

$$a_A = \frac{M_B a}{M}, a_B = \frac{M_A a}{M}, E_A = \frac{M_B^3}{M^2}, E_B = \frac{M_A^3}{M^2} \quad (3)$$

This translates the conservative part of the binary problem (2) into a single body one

$$H = \frac{M_A \sqrt{1 - \frac{4GM_B^2}{aM(1-e^2)} + \frac{4G^2 M_B^4}{a^2 M^2 (1-e^2)}}}{\sqrt{1 - \frac{(3+e^2)GM_B^2}{aM(1-e^2)}}} + \left(\begin{smallmatrix} A \\ \updownarrow \\ B \end{smallmatrix} \right), J = \frac{GM_A M_B a (1 - e^2)}{M \sqrt{\frac{aM(1-e^2)}{GM_B^2}} \sqrt{1 - \frac{(3+e^2)GM_B^2}{aM(1-e^2)}}} \left(\begin{smallmatrix} A \\ \updownarrow \\ B \end{smallmatrix} \right). \quad (4)$$

The low-speed-weak-field expansion of (4) matches with the PN-series of GR at any given order n , up to some functions of lower order conservative E_{n-1} and J_{n-1} .

eXact is just in this sense



dfzeng
BJUT, Beijing

motivation

XOB idea

**Damping
Origin**

Conclusion

Appendix

XOB hamiltonian and its equivalence with PN-expansion

The lagrangian of the two particles in the patch-worked geometry reads

$$L = -M_A \sqrt{-g_{\mu\nu}^A \dot{x}_A^\mu \dot{x}_A^\nu} - M_B \sqrt{-g_{\mu\nu}^B \dot{x}_B^\mu \dot{x}_B^\nu} + L_{\text{dissipation}} \quad (2)$$

$$g_{\mu\nu}^A \dot{x}_A^\mu \dot{x}_A^\nu = -h_b + h_b^{-1} \dot{a}_A^2 + \dot{\phi}_A^2 a_A^2, g_{\mu\nu}^B \dot{x}_B^\mu \dot{x}_B^\nu \text{ similar}$$

requiring the central of the patch-worked geometry be fixed and the two patches' inspiral be synchronous leads to

$$a_A = \frac{M_B a}{M}, a_B = \frac{M_A a}{M}, E_A = \frac{M_B^3}{M^2}, E_B = \frac{M_A^3}{M^2} \quad (3)$$

This translates the conservative part of the binary problem (2) into a single body one

$$H = \frac{M_A \sqrt{1 - \frac{4GM_B^2}{aM(1-e^2)} + \frac{4G^2 M_B^4}{a^2 M^2 (1-e^2)}}}{\sqrt{1 - \frac{(3+e^2)GM_B^2}{aM(1-e^2)}}} + \left(\begin{matrix} A \\ \updownarrow \\ B \end{matrix} \right), J = \frac{GM_A M_B a (1 - e^2)}{M \sqrt{\frac{aM(1-e^2)}{GM_B^2}} \sqrt{1 - \frac{(3+e^2)GM_B^2}{aM(1-e^2)}}} \left(\begin{matrix} A \\ \updownarrow \\ B \end{matrix} \right). \quad (4)$$

The low-speed-weak-field expansion of (4) matches with the PN-series of GR at any given order n , up to some functions of lower order conservative E_{n-1} and J_{n-1} .

eXact is just in this sense



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

XOB dissipation dynamics and gravitational wave forms

Consider the dissipation caused by GW radiation, $\mathbf{H}$ and $\mathbf{J}$ vary with time, using quadrupole formula

$$\frac{dH(a, e)}{d[a, e]} \frac{d[a, e]}{dt} = -F_{\text{diss}}, \quad \frac{dJ(a, e)}{d[a, e]} \frac{d[a, e]}{dt} = -J_{\text{diss}}, \quad (5)$$

$$F_{\text{diss}} = F^{\text{co}} \zeta^2 \frac{1 + \frac{73}{24}e^2 + \frac{37}{96}e^4}{(1 - e^2)^{7/2}}, \quad \zeta = \frac{\sin 4GMz/a}{4GMz/a} \quad (6)$$

$$J_{\text{diss}} = \frac{F^{\text{co}}}{\omega} \zeta^2 \frac{1 + \frac{7}{8}e^2}{(1 - e^2)^2}, \quad F^{\text{co}} \sim \frac{32}{5} \frac{G\mu^2 a^4 \omega^6}{c^5} \quad (7)$$

Eqs(5) can be solved numerically, the GWform can then be computed routinely

$$h_{+, \times}^{\ell m=22} \propto \frac{2G^2 M \mu}{a R c^4} \frac{\zeta H_{+, \times}}{1 - e^2}, \quad H_+ = \frac{(e^2 \cos 2\phi - 3e \cos \phi - 2) \cos 2\phi}{-e(2 \sin \phi + e \sin 2\phi) \sin 2\phi}, \quad H_{\times} = \frac{\dots \sin 2\phi}{+\dots \cos 2\phi} \quad (8)$$

where ζ is a factor of radiation activity. For point-like particles, $\zeta \equiv 1$. But for arc-line-like objects, ζ -varies from 1 $\rightarrow$ 0 as its length grows. The following figure compares the GWform from three types of computational route



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

XOB dissipation dynamics and gravitational wave forms

Consider the dissipation caused by GW radiation, $\mathbf{H}$ and $\mathbf{J}$ vary with time, using quadrupole formula

$$\frac{dH(a, e)}{d[a, e]} \frac{d[a, e]}{dt} = -F_{\text{diss}}, \quad \frac{dJ(a, e)}{d[a, e]} \frac{d[a, e]}{dt} = -J_{\text{diss}}, \quad (5)$$

$$F_{\text{diss}} = F^{\text{co}} \zeta^2 \frac{1 + \frac{73}{24}e^2 + \frac{37}{96}e^4}{(1 - e^2)^{7/2}}, \quad \zeta = \frac{\sin 4GMz/a}{4GMz/a} \quad (6)$$

$$J_{\text{diss}} = \frac{F^{\text{co}}}{\omega} \zeta^2 \frac{1 + \frac{7}{8}e^2}{(1 - e^2)^2}, \quad F^{\text{co}} \sim \frac{32}{5} \frac{G\mu^2 a^4 \omega^6}{c^5} \quad (7)$$

Eqs(5) can be solved numerically, the GWform can then be computed routinely

$$h_{+, \times}^{\ell m=22} \propto \frac{2G^2 M \mu}{a R c^4} \frac{\zeta H_{+, \times}}{1 - e^2}, \quad H_+ = \frac{(e^2 \cos 2\phi - 3e \cos \phi - 2) \cos 2\phi}{-e(2 \sin \phi + e \sin 2\phi) \sin 2\phi}, \quad H_{\times} = \frac{\dots \sin 2\phi}{+\dots \cos 2\phi} \quad (8)$$

where ζ is a factor of radiation activity. For point-like particles, $\zeta \equiv 1$. But for arc-line-like objects, ζ -varies from 1 $\rightarrow$ 0 as its length grows. The following figure compares the GWform from three types of computational route



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

the GW predicted by XOB and comparison with other methods



dfzeng
BJUT, Beijing

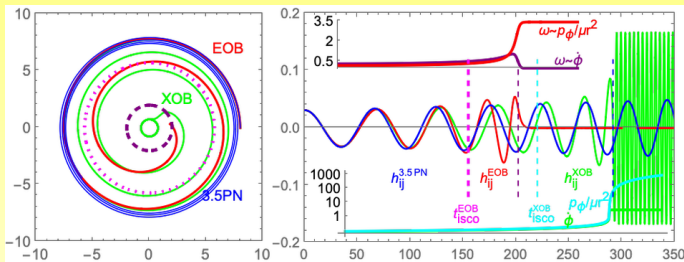
motivation

XOB idea

Damping
Origin

Conclusion

Appendix



- In Newton and Post-Newton(3.5PN), the GW of two point-like particles' merger process grows monotonically because two such objects has infinitely amount of potential energy to radiate
- EOB re-sums all known PN series, but its GWform decays in a semi cycle inspiral motion, this is non-physical and self-inconsistent
- XOB produces acceptable GWforms, although no damping feature at late time, this is because we pre-assumed the central of the two participants coincide so infinitely amount of potential-energy is injected and support the constant GW-radiation

the GW predicted by XOB and comparison with other methods



dfzeng
BJUT, Beijing

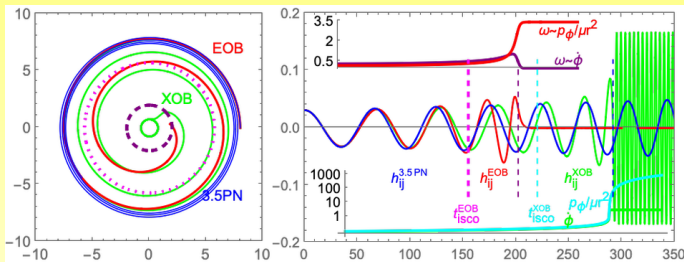
motivation

XOB idea

Damping
Origin

Conclusion

Appendix



- In Newton and Post-Newton(3.5PN), the GW of two point-like particles' merger process grows monotonically because two such objects has infinitely amount of potential energy to radiate
- EOB re-sums all known PN series, but its GWform decays in a semi cycle inspiral motion, this is non-physical and self-inconsistent
- XOB produces acceptable GWforms, although no damping feature at late time, this is because we pre-assumed the central of the two participants coincide so infinitely amount of potential-energy is injected and support the constant GW-radiation

the GW predicted by XOB and comparison with other methods



dfzeng
BJUT, Beijing

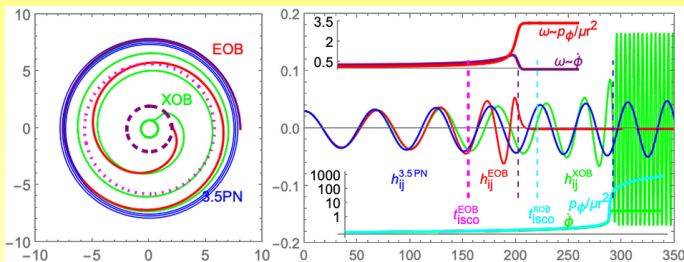
motivation

XOB idea

Damping
Origin

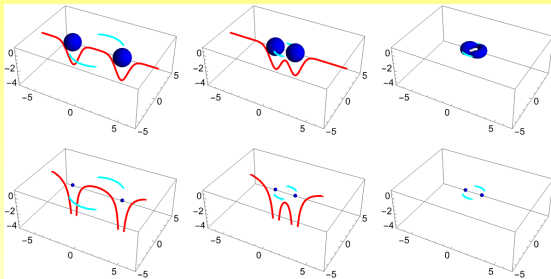
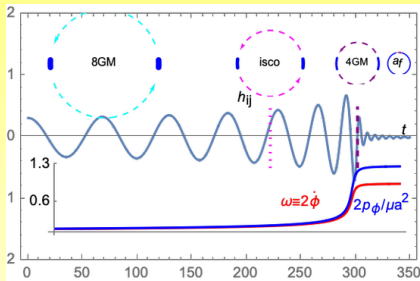
Conclusion

Appendix



- In Newton and Post-Newton(3.5PN), the GW of two point-like particles' merger process grows monotonically because two such objects has infinitely amount of potential energy to radiate
- EOB re-sums all known PN series, but its GWform decays in a semi cycle inspiral motion, this is non-physical and self-inconsistent
- XOB produces acceptable GWforms, although no damping feature at late time, this is because we pre-assumed the central of the two participants coincide so infinitely amount of potential-energy is injected and support the constant GW-radiation

the GW predicted by XOB and comparison with other methods



- to obtain damping gravitation wave, we have to allow the singularity of the system to experience elongation, bending thus rotational symmetry enhancement
- This is understandable if and only if the merger participant carries no-horizon and no-singularity at all
- NR provides us expected damping because it allows the AH of merger participants to experience shape deformation conformal with the singularity in XOB
- in this sense, what NR provides us is an equivalent description for what happens inside the no-horizon non-singular objects it claims as BH



dfzeng
BJUT, Beijing

motivation

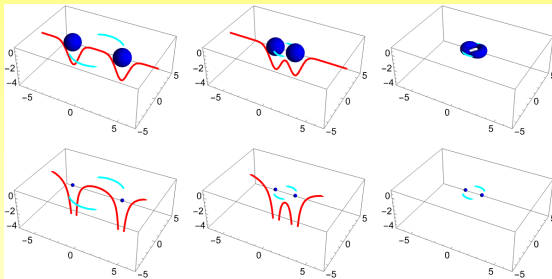
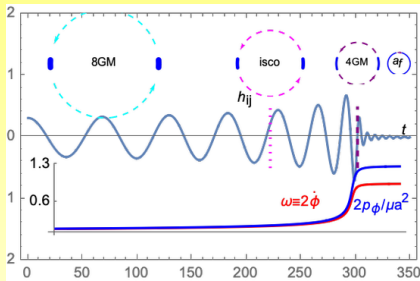
XOB idea

Damping
Origin

Conclusion

Appendix

the GW predicted by XOB and comparison with other methods



- to obtain damping gravitation wave, we have to allow the singularity of the system to experience elongation, bending thus rotational symmetry enhancement
- This is understandable if and only if the merger participant carries no-horizon and no-singularity at all
- NR provides us expected damping because it allows the AH of merger participants to experience shape deformation conformal with the singularity in XOB
- in this sense, what NR provides us is an equivalent description for what happens inside the no-horizon non-singular objects it claims as BH



dfzeng
BJUT, Beijing

motivation

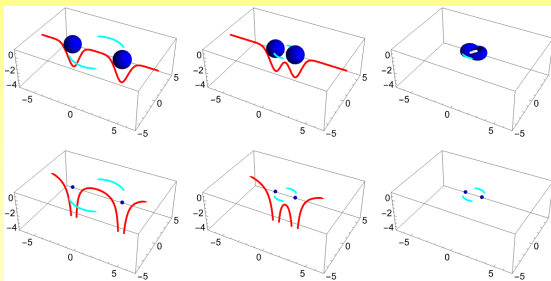
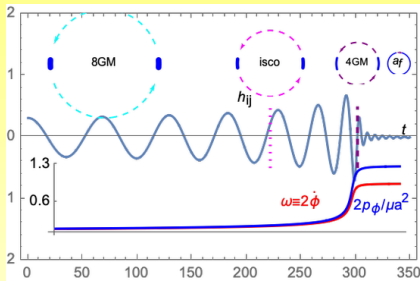
XOB idea

Damping
Origin

Conclusion

Appendix

the GW predicted by XOB and comparison with other methods



- to obtain damping gravitation wave, we have to allow the singularity of the system to experience elongation, bending thus rotational symmetry enhancement
- This is understandable if and only if the merger participant carries no-horizon and no-singularity at all
- NR provides us expected damping because it allows the AH of merger participants to experience shape deformation conformal with the singularity in XOB
- in this sense, what NR provides us is an equivalent description for what happens inside the no-horizon non-singular objects it claims as BH



dfzeng
BJUT, Beijing

motivation

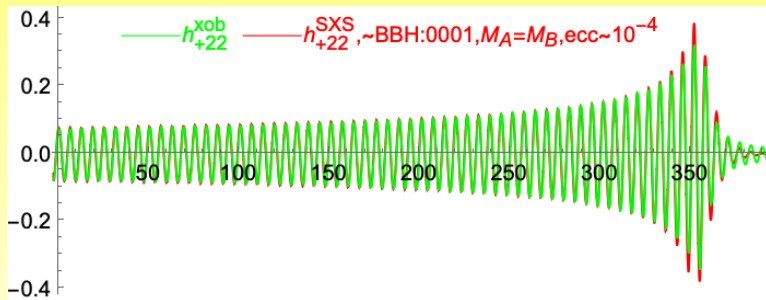
XOB idea

Damping
Origin

Conclusion

Appendix

No-horizon non-singular internals – evidences from the GWform of XOB



As long as the singularity of the merger participant is allowed to experience elongation and bending, we can get WForms of the process matching with NR to 99% precision. since XOB adopts a different time definition relative to NR, we do not directly compare the $\mathbf{h}-t$ WFs of the two method, but the $\mathbf{h}-\phi$ WFs

This matching persists even when we add eccentricity to the initial orbit of the two merger participants

The elongation factor $z(t)$ of the mass distribution need be parametrized



dfzeng
BJUT, Beijing

motivation

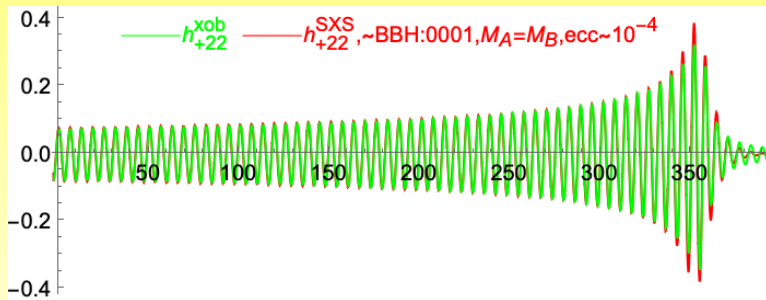
XOB idea

Damping
Origin

Conclusion

Appendix

No-horizon non-singular internals – evidences from the GWform of XOB



As long as the singularity of the merger participant is allowed to experience elongation and bending, we can get WForms of the process matching with NR to 99% precision. since XOB adopts a different time definition relative to NR, we do not directly compare the $h-t$ WFs of the two method, but the $h-\phi$ WFs

This matching persists even when we add eccentricity to the initial orbit of the two merger participants

The elongation factor $z(t)$ of the mass distribution need be parametrized



dfzeng
BJUT, Beijing

motivation

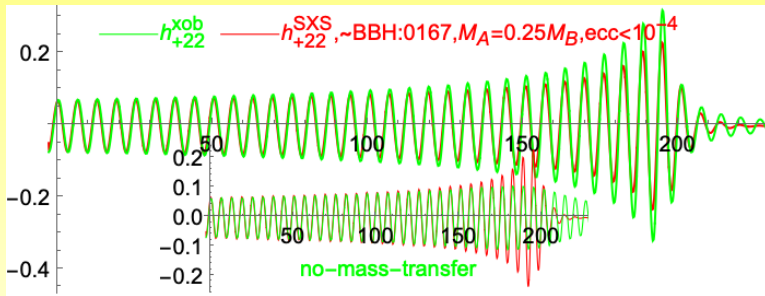
XOB idea

Damping
Origin

Conclusion

Appendix

No-horizon non-singular internals – more evidences from the GWform of XOB



If we consider the WF following from the coalescence of un-equal mass BHB system, since the with-horizon with-singularity structure allows no mass transfer between the two merger participants, the WF of XOB deviates from NR remarkably

To get GWforms from XOB matching with NR, we have to allow masses transfer from the big-fat one to the small-thin one



dfzeng
BJUT, Beijing

motivation

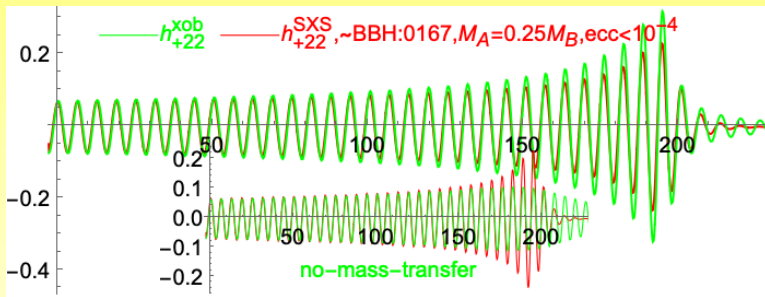
XOB idea

Damping
Origin

Conclusion

Appendix

No-horizon non-singular internals – more evidences from the GWform of XOB



If we consider the WF following from the coalescence of un-equal mass BHB system, since the with-horizon with-singularity structure allows no mass transfer between the two merger participants, the WF of XOB deviates from NR remarkably

To get GWforms from XOB matching with NR, we have to allow masses transfer from the big-fat one to the small-thin one



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

No-horizon non-singular internals – evidence from the residue mass of BHB



dfzeng
BJUT, Beijing

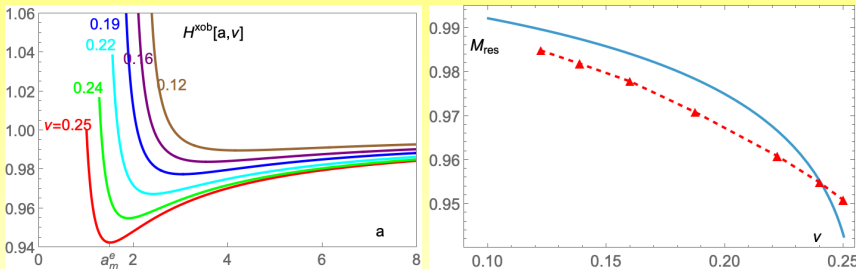
motivation

XOB idea

Damping
Origin

Conclusion

Appendix



- the minimal value of XOB hamiltonian equals to the mass of BHB merger products, the latter (residual) as a function of the symmetric mass ratio
- the initially $m_1 = m_2 = 1/2$ system has minimal residue mass 0.9436, $\nu = \frac{m_1 m_2}{m_1 + m_2}$; as the mass ratio deviates from 1, the residue mass increases
- during the merger process, if no mass-transferring happens, the residue mass will grows more rapidly as $\nu \rightarrow 0$. However, NR yields the red scattered points

No-horizon non-singular internals – evidence from the residue mass of BHB



dfzeng
BJUT, Beijing

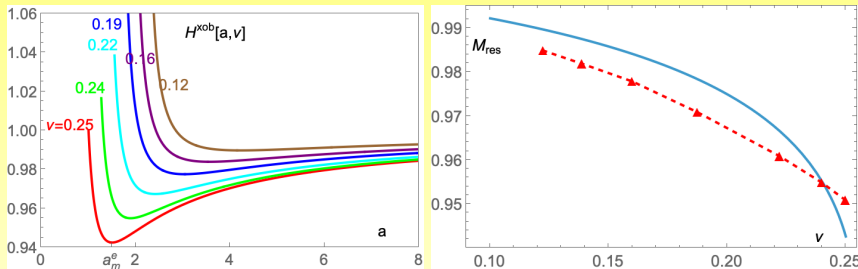
motivation

XOB idea

Damping
Origin

Conclusion

Appendix



- the minimal value of XOB hamiltonian equals to the mass of BHB merger products, the latter (residual) as a function of the symmetric mass ratio
- the initially $m_1 = m_2 = 1/2$ system has minimal residue mass 0.9436, $\nu = \frac{m_1 m_2}{m_1 + m_2}$; as the mass ratio deviates from 1, the residue mass increases
- during the merger process, if no mass-transferring happens, the residue mass will grows more rapidly as $\nu \rightarrow 0$. However, NR yields the red scattered points

No-horizon non-singular internals – evidence from the residue mass of BHB



dfzeng
BJUT, Beijing

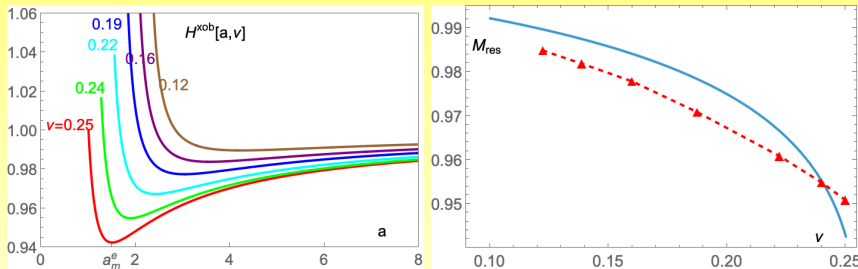
motivation

XOB idea

Damping
Origin

Conclusion

Appendix



- the minimal value of XOB hamiltonian equals to the mass of BHB merger products, the latter (residual) as a function of the symmetric mass ratio
- the initially $m_1 = m_2 = 1/2$ system has minimal residue mass 0.9436, $\nu = \frac{m_1 m_2}{m_1 + m_2}$; as the mass ratio deviates from 1, the residue mass increases
- during the merger process, if no mass-transferring happens, the residue mass will grows more rapidly as $\nu \rightarrow 0$. However, NR yields the red scattered points

No-horizon non-singular internals – evidence from the residue mass of BHB



dfzeng
BJUT, Beijing

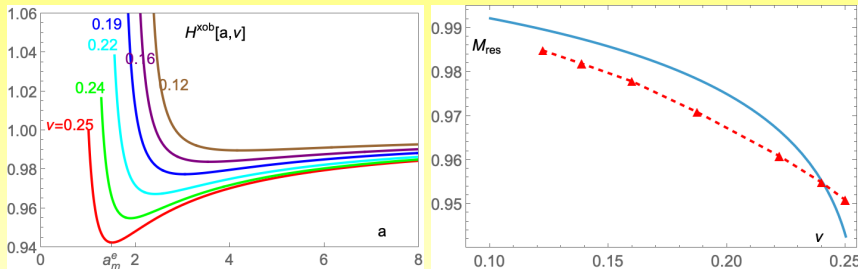
motivation

XOB idea

Damping
Origin

Conclusion

Appendix



- the minimal value of XOB hamiltonian equals to the mass of BHB merger products, the latter (residual) as a function of the symmetric mass ratio
- the initially $m_1 = m_2 = 1/2$ system has minimal residue mass 0.9436, $\nu = \frac{m_1 m_2}{m_1 + m_2}$; as the mass ratio deviates from 1, the residue mass increases
- during the merger process, if no mass-transferring happens, the residue mass will grows more rapidly as $\nu \rightarrow 0$. However, NR yields the red scattered points

Conclusion

- If the BHs simulated in the NR and measured in the AO carry singularity, then their singularity configuration's variation during the merger process is hardly understandable in GR.
 - XOB provides an eXact One Body approach to the conservative part of binary merger dynamics in GR. Supplemented with simple quadrupole formula and a phenomenological parameterization of the system's mass distribution, this approach can produce GWforms agreeing with those of NR to 99% degree.
 - According to XOB, the late time damping of GWform of BHB process reveals the no-horizon non-singular structure of BHs. What NR present to us is an equivalent description for the merger behavior of no-horizon non-singularity objects with techniques of shape-deformable apparent horizon
 - The GW following from the coalescence of no-horizon non-singularity "BHs" may pollute the signal of dark-matters wrapping BHs with exact horizon and singularity.
- ref: 2505.14749(in updating), 2505.14750(in updating), EPJC84(2024)

Thanks for your attention



dfzeng
BJUT, Beijing

motivation

XOB idea

**Damping
Origin**

Conclusion

Appendix

Conclusion

- If the BHs simulated in the NR and measured in the AO carry singularity, then their singularity configuration's variation during the merger process is hardly understandable in GR.
 - XOB provides an eXact One Body approach to the conservative part of binary merger dynamics in GR. Supplemented with simple quadrupole formula and a phenomenological parameterization of the system's mass distribution, this approach can produce GWforms agreeing with those of NR to 99% degree.
 - According to XOB, the late time damping of GWform of BHB process reveals the no-horizon non-singular structure of BHs. What NR present to us is an equivalent description for the merger behavior of no-horizon non-singularity objects with techniques of shape-deformable apparent horizon
 - The GW following from the coalescence of no-horizon non-singularity "BHs" may pollute the signal of dark-matters wrapping BHs with exact horizon and singularity.
- ref: 2505.14749(in updating), 2505.14750(in updating), EPJC84(2024)

Thanks for your attention



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

Conclusion

- If the BHs simulated in the NR and measured in the AO carry singularity, then their singularity configuration's variation during the merger process is hardly understandable in GR.
 - XOB provides an eXact One Body approach to the conservative part of binary merger dynamics in GR. Supplemented with simple quadrupole formula and a phenomenological parameterization of the system's mass distribution, this approach can produce GWforms agreeing with those of NR to 99% degree.
 - According to XOB, the late time damping of GWform of BHB process reveals the no-horizon non-singular structure of BHs. What NR present to us is an equivalent description for the merger behavior of no-horizon non-singularity objects with techniques of shape-deformable apparent horizon
 - The GW following from the coalescence of no-horizon non-singularity "BHs" may pollute the signal of dark-matters wrapping BHs with exact horizon and singularity.
- ref: 2505.14749(in updating), 2505.14750(in updating), EPJC84(2024)

Thanks for your attention



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

Conclusion

- If the BHs simulated in the NR and measured in the AO carry singularity, then their singularity configuration's variation during the merger process is hardly understandable in GR.
- XOB provides an eXact One Body approach to the conservative part of binary merger dynamics in GR. Supplemented with simple quadrupole formula and a phenomenological parameterization of the system's mass distribution, this approach can produce GWforms agreeing with those of NR to 99% degree.
- According to XOB, the late time damping of GWform of BHB process reveals the no-horizon non-singular structure of BHs. What NR present to us is an equivalent description for the merger behavior of no-horizon non-singularity objects with techniques of shape-deformable apparent horizon
- The GW following from the coalescence of no-horizon non-singularity "BHs" may pollute the signal of dark-matters wrapping BHs with exact horizon and singularity.

ref: 2505.14749(in updating), 2505.14750(in updating), EPJC84(2024)

Thanks for your attention



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

Conclusion

- If the BHs simulated in the NR and measured in the AO carry singularity, then their singularity configuration's variation during the merger process is hardly understandable in GR.
 - XOB provides an eXact One Body approach to the conservative part of binary merger dynamics in GR. Supplemented with simple quadrupole formula and a phenomenological parameterization of the system's mass distribution, this approach can produce GWforms agreeing with those of NR to 99% degree.
 - According to XOB, the late time damping of GWform of BHB process reveals the no-horizon non-singular structure of BHs. What NR present to us is an equivalent description for the merger behavior of no-horizon non-singularity objects with techniques of shape-deformable apparent horizon
 - The GW following from the coalescence of no-horizon non-singularity "BHs" may pollute the signal of dark-matters wrapping BHs with exact horizon and singularity.
- ref: 2505.14749(in updating), 2505.14750(in updating), EPJC84(2024)

Thanks for your attention



dfzeng
BJUT, Beijing

motivation

XOB idea

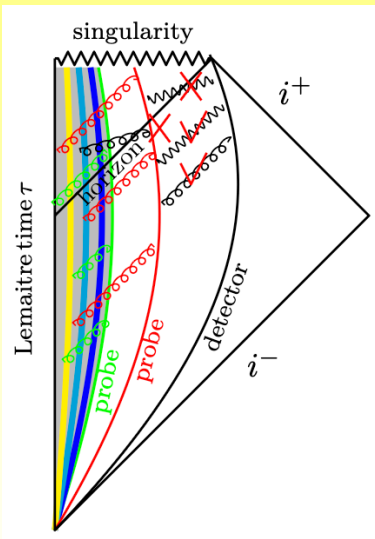
Damping
Origin

Conclusion

Appendix

The inner structure of BHs is problem of philosophy affecting observation directly

- The no-horizon non-singularity structure of BHs simulated in NR and observed in AstrObsv is understandable in GR language.
 - Due to gravitational time dilation, the formation of horizon and singularity happens beyond the domain of time definition of all outside probes
 - This is not an observer effects, but a question whose answered is not appointed in GR: Of the maximally extended space-time and the space-time coverable by the time definition during which our probe is selected and monitored, which is complete?
 - my position: the latter is equally complete as the former. sticking on the former is similar with insisting a quantum particle must follow some definite orbit when it is not observed
- A philosophy, but a philosophy directly affecting our computation & comparison with observations



dfzeng
BJUT, Beijing

motivation

XOB idea

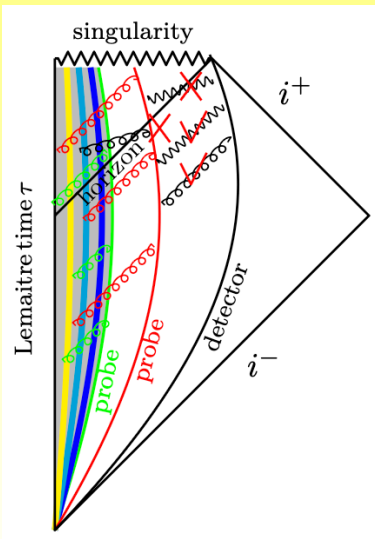
**Damping
Origin**

Conclusion

Appendix

The inner structure of BHs is problem of philosophy affecting observation directly

- The no-horizon non-singularity structure of BHs simulated in NR and observed in AstrObsv is understandable in GR language.
 - Due to gravitational time dilation, the formation of horizon and singularity happens beyond the domain of time definition of all outside probes
 - This is not an observer effects, but a question whose answered is not appointed in GR: Of the maximally extended space-time and the space-time coverable by the time definition during which our probe is selected and monitored, which is complete?
 - my position: the latter is equally complete as the former. sticking on the former is similar with insisting a quantum particle must follow some definite orbit when it is not observed
- A philosophy, but a philosophy directly affecting our computation & comparison with observations



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

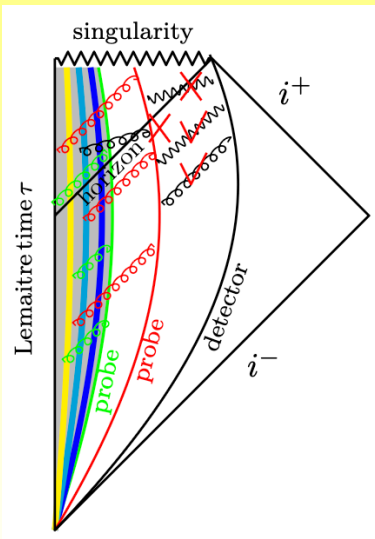
Conclusion

Appendix

The inner structure of BHs is problem of philosophy affecting observation directly

- The no-horizon non-singularity structure of BHs simulated in NR and observed in AstrObsv is understandable in GR language.
- Due to gravitational time dilation, the formation of horizon and singularity happens beyond the domain of time definition of all outside probes
- This is not an observer effects, but a question whose answered is not appointed in GR: Of the maximally extended space-time and the space-time coverable by the time definition during which our probe is selected and monitored, which is complete?
- my position: the latter is equally complete as the former. sticking on the former is similar with insisting a quantum particle must follow some definite orbit when it is not observed

A philosophy, but a philosophy directly affecting our computation & comparison with observations



dfzeng
BJUT, Beijing

motivation

XOB idea

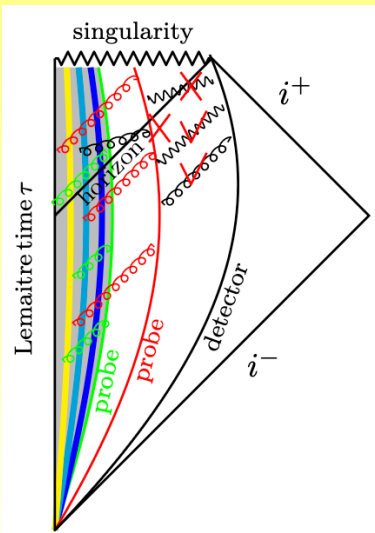
Damping
Origin

Conclusion

Appendix

The inner structure of BHs is problem of philosophy affecting observation directly

- The no-horizon non-singularity structure of BHs simulated in NR and observed in AstrObsv is understandable in GR language.
 - Due to gravitational time dilation, the formation of horizon and singularity happens beyond the domain of time definition of all outside probes
 - This is not an observer effects, but a question whose answered is not appointed in GR: Of the maximally extended space-time and the space-time coverable by the time definition during which our probe is selected and monitored, which is complete?
 - my position: the latter is equally complete as the former. sticking on the former is similar with insisting a quantum particle must follow some definite orbit when it is not observed
- A philosophy, but a philosophy directly affecting our computation & comparison with observations



dfzeng
BJUT, Beijing

motivation

XOB idea

Damping
Origin

Conclusion

Appendix

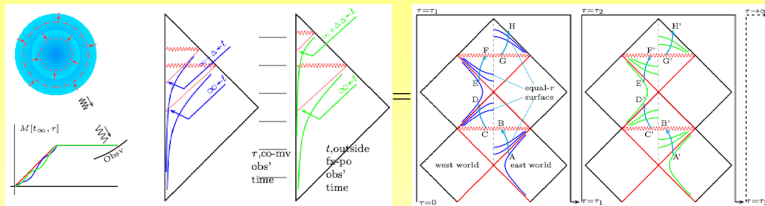
motivation

XOB idea

Damping Origin

Conclusion

Appendix



- 13-13