

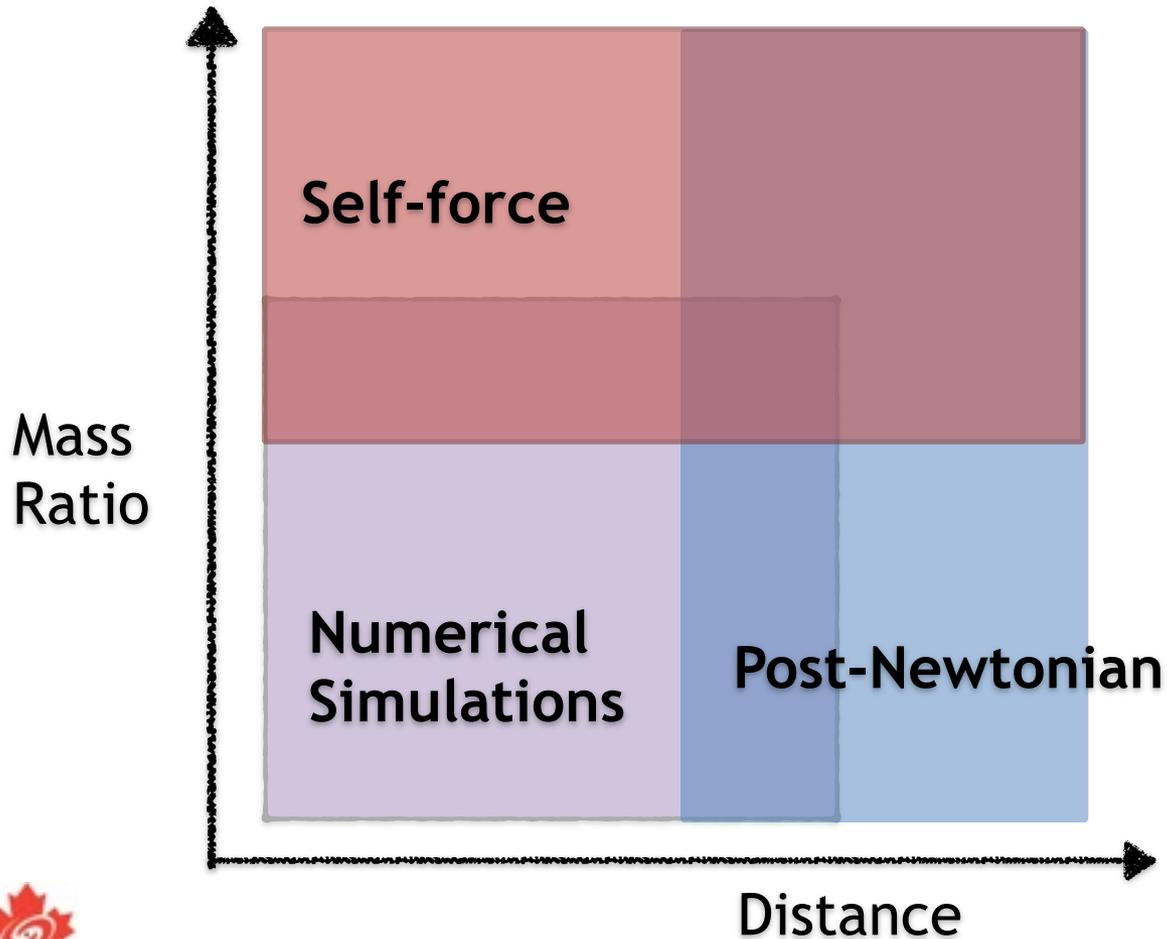
Extracting the redshift factor in binary black hole simulations

Aaron Zimmerman,
Adam Lewis, Harald Pfeiffer (CITA)
arXiv:1606.08056

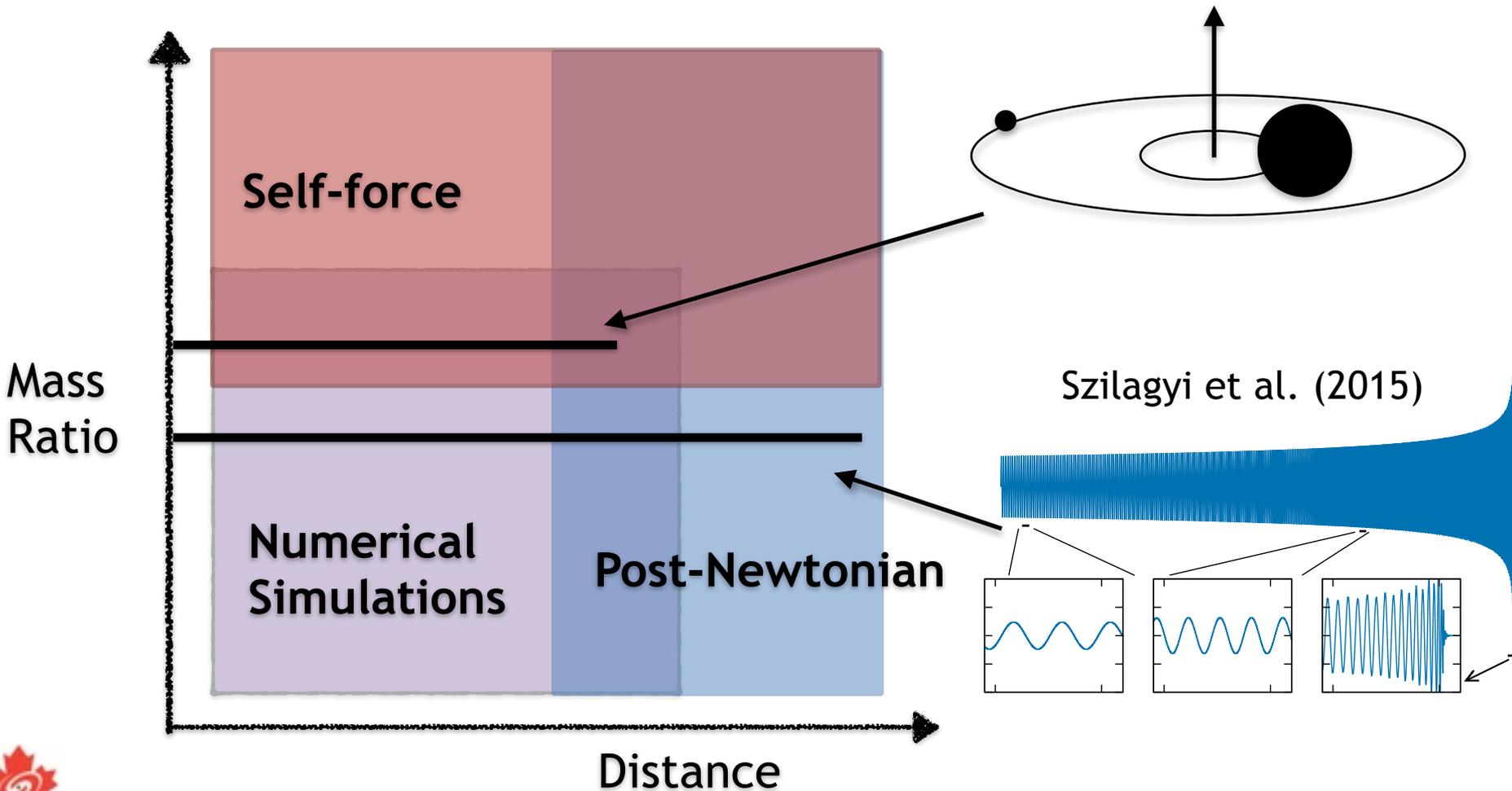
GR21
July 11, 2016



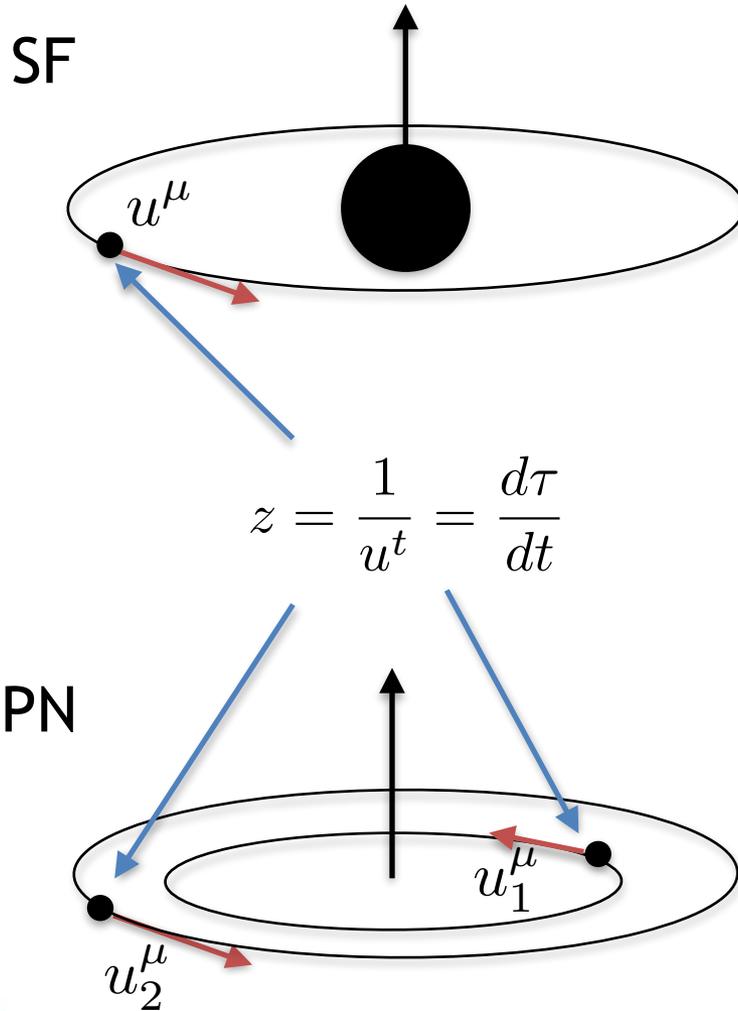
Two body problem



Two body problem



Redshift factor z

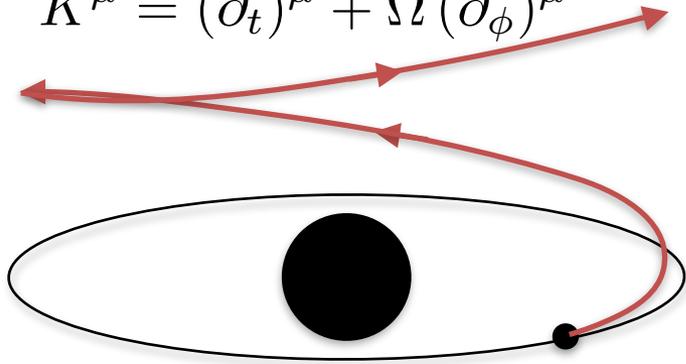


- Invariant quantity in SF and PN theories
- Wealth of connections: SF, PN, EOB
- Sims have extended bodies
- Interface w/ NR: connect to surface grav



Redshift and surface gravity

$$K^\mu = (\partial_t)^\mu + \Omega (\partial_\phi)^\mu$$

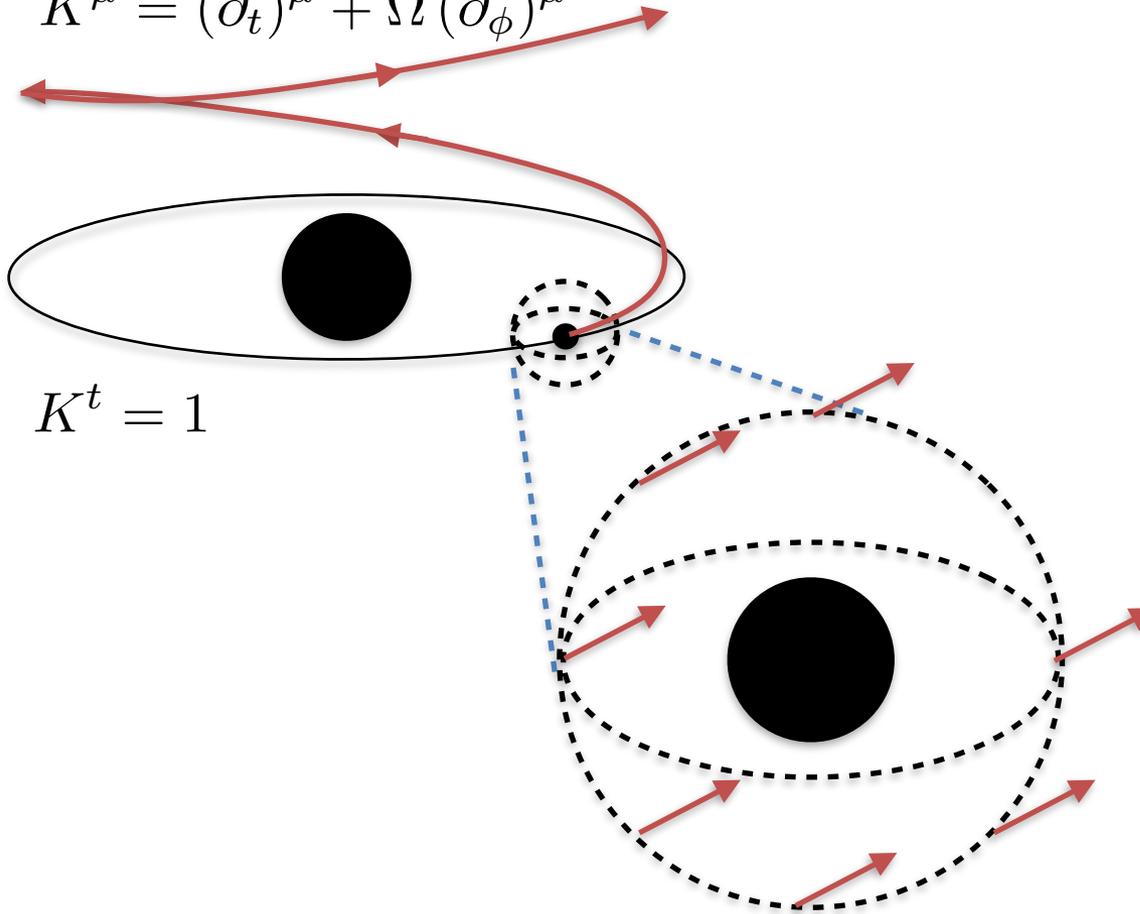


$$K^t = 1$$



Redshift and surface gravity

$$K^\mu = (\partial_t)^\mu + \Omega (\partial_\phi)^\mu$$

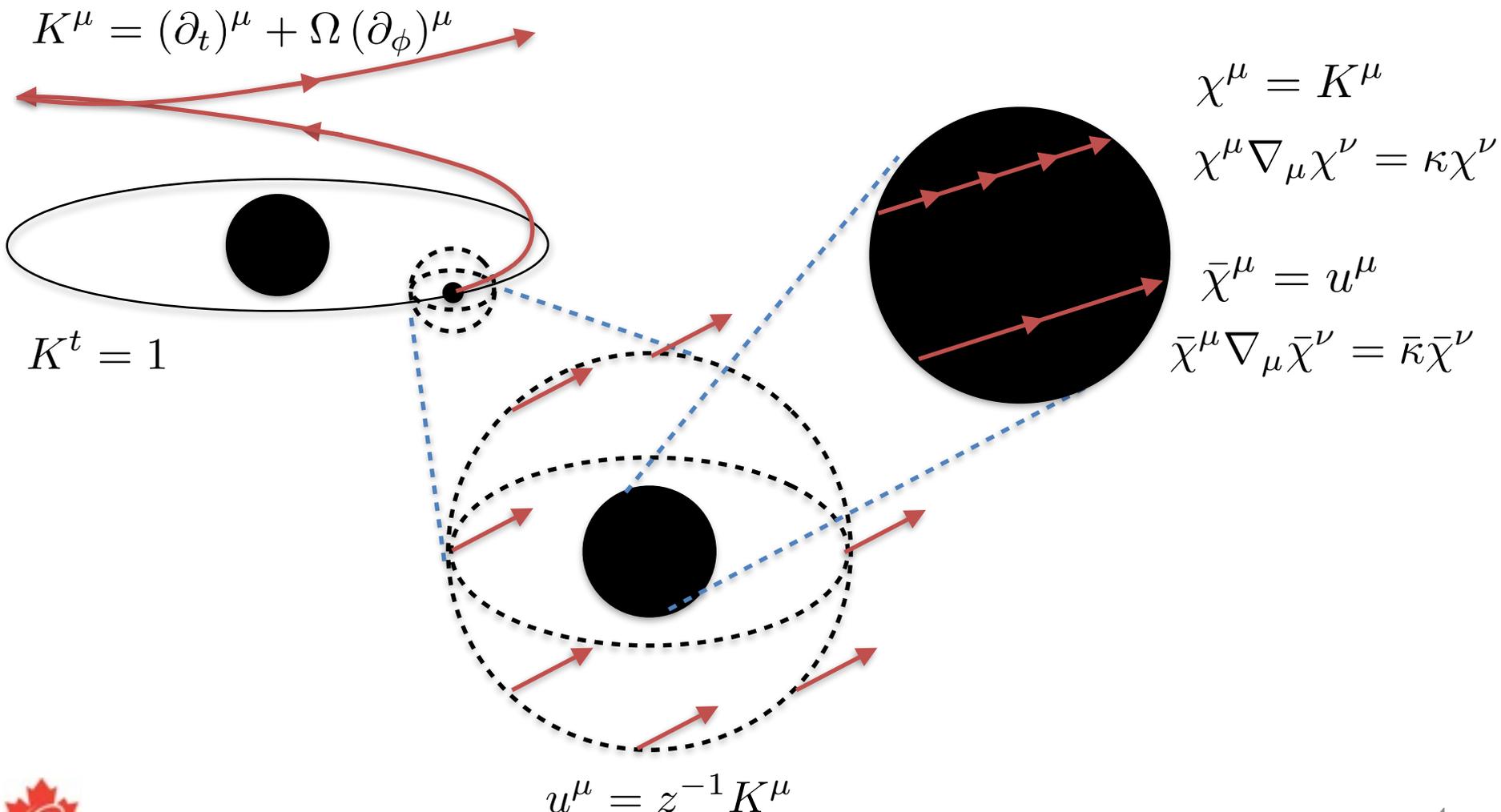


$$K^t = 1$$

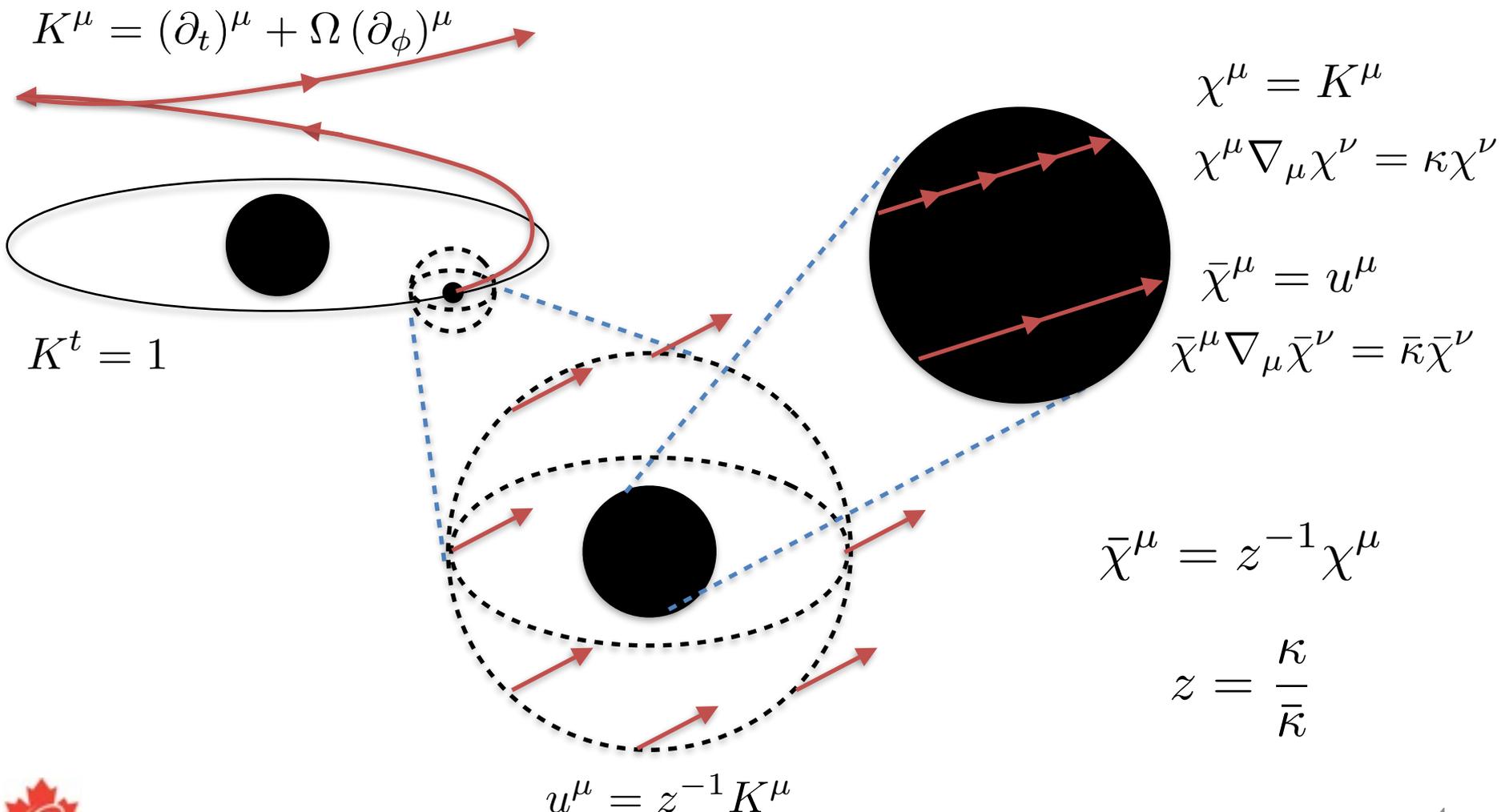
$$u^\mu = z^{-1} K^\mu$$



Redshift and surface gravity



Redshift and surface gravity



Redshift in NR

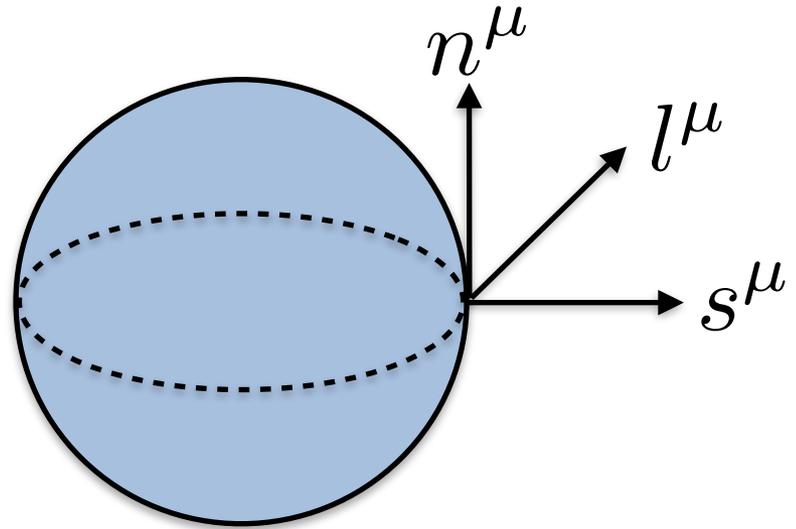
- Normalization absent
- Consider rescaling

$$l^\mu \rightarrow \alpha l^\mu \quad \kappa(l) \rightarrow \alpha \kappa(l)$$

- Rescaling invariant z

$$z = \frac{\kappa(l)}{l^t \bar{\kappa}} \quad z \rightarrow z$$

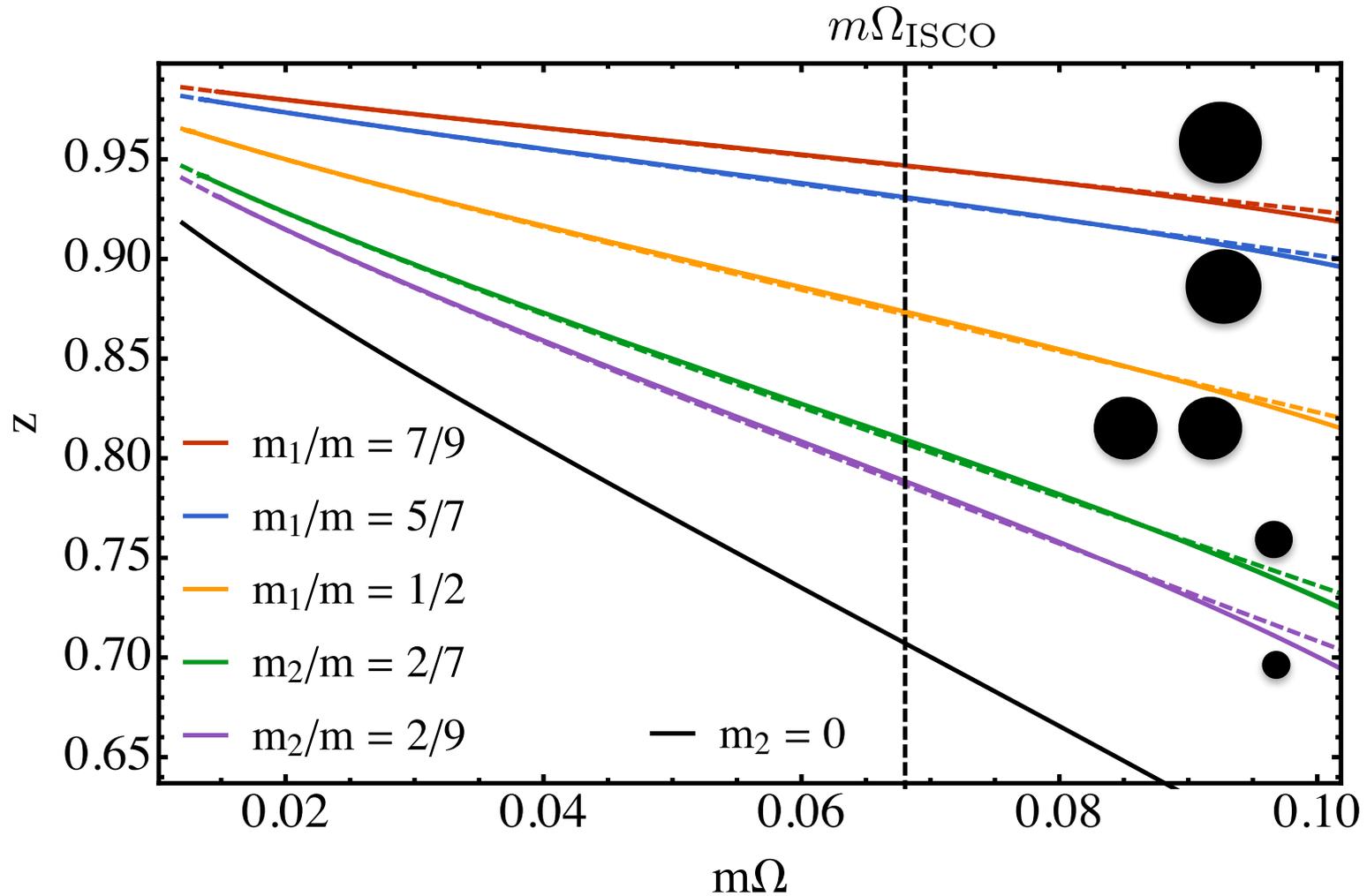
- Don't access EH: use AH
- HKV only approximate



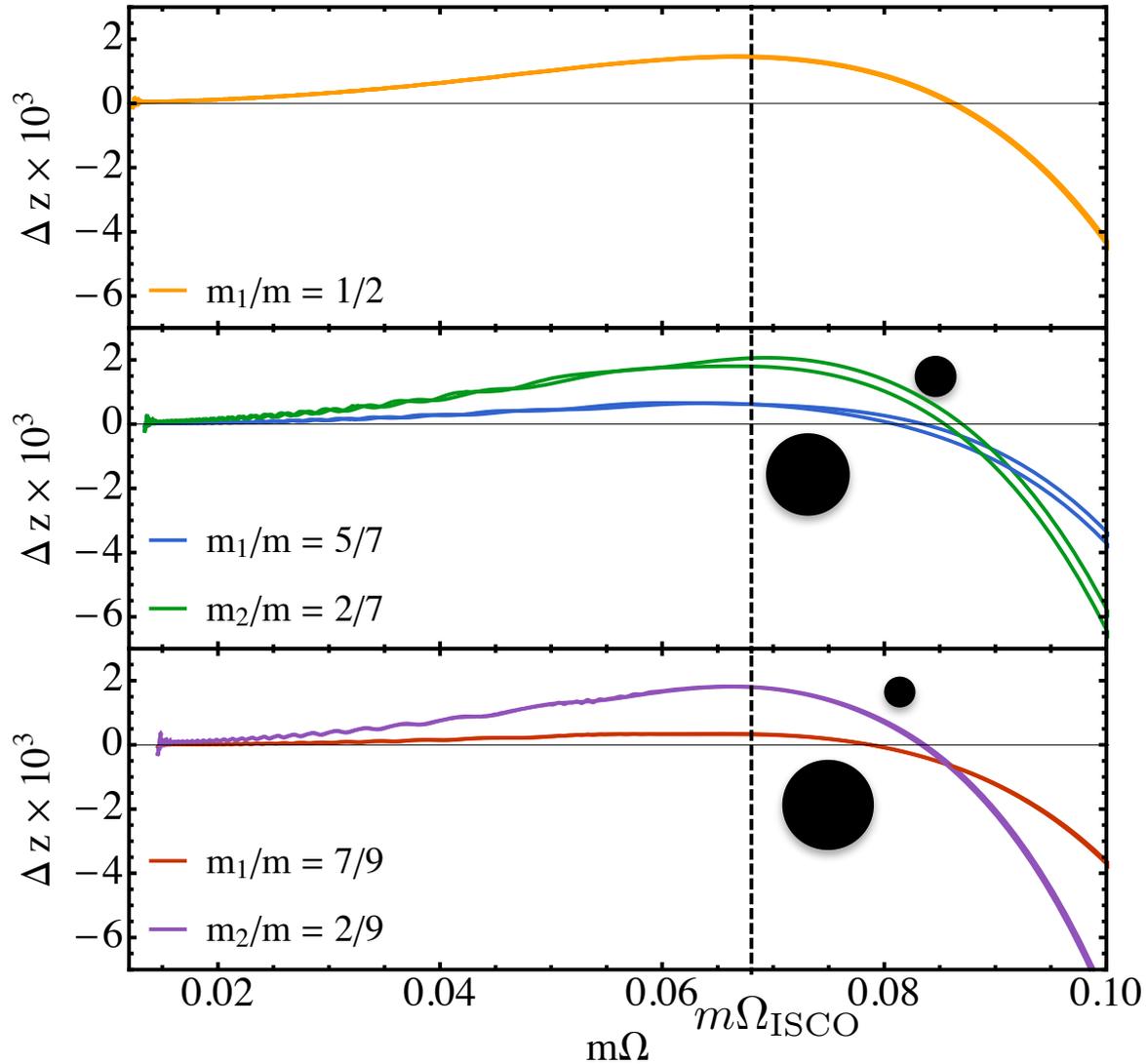
$$\langle z \rangle = \frac{\int dA z(\theta^B)}{A}$$



Redshift factor in NR

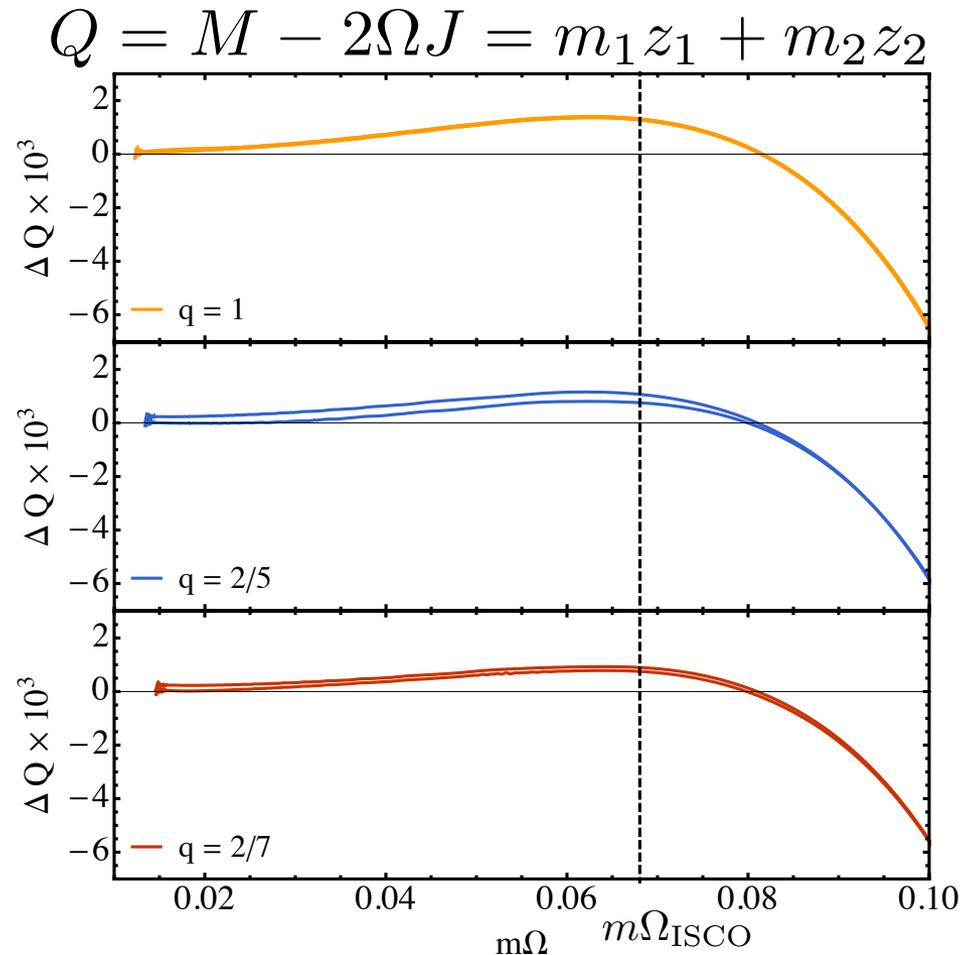


Redshift vs PN



First law of binary black holes

- Thermodynamic relations for circular binaries
- Connect between local and global properties
- Many uses in SF, PN, EOB
- Test w/ our z



Summary and outlook

- Extracted redshift in NR
- Confirmed first law for binaries to 1:1000
- Higher mass ratios, high order SF
- Spinning, eccentric binaries (see poster by Adam G.M. Lewis)
- Testing and extending first law of binary black holes

