

Odd considerations...

- Detection & characterisation of E/IMRI dynamics
- Properties of the low-mass objects
- Properties of the MBHs
- Cosmology
- Test of GR/Kerr metric

Characterisation of E/IMRI dynamics

- Reminder: different channels
 - Std (spherical cluster with relax): $e > 0$, i random
 - Binary tidal splitting; tidal capture of giant core: $e = 0$, i rand
 - e maybe not strictly 0
 - Disk processes (capture, in-disk formation): $e = 0$, $i = 0$
 - May warping create out-of-equatorial-plan EMRI?
- Precision of e & i measurement should be more than enough to distinguish channels
 - Small e (few 0.01) should be measurable
 - Zoomwhirl phase: short and require very large starting e ; probably not detectable (really? What about ring-down?)
 - If $e > 0.1$ (?), could detect 3d harm. even if 2nd is out of band

Properties of low-mass objects

- Mass: “easy” to measure precisely
 - In std scenario, mass segregation is key: massive objects “massively” over-represented. Unique way to establish “maximum” mass for stellar BHs? (nice for stellar evol, SN models)
 - For binary splitting, not clear yet what masses will be selected (not always the most massive member of the binary)
 - Hypervelocity stars can help to calibrate/check models for rates
 - Aside: S stars indicate that
 - We don't understand star formation or transport in galactic nuclei
 - We can get some independent rate estimate for EMRIs, maybe...

Properties of low-mass objects

- Spin:

- Forget it for EMRI (?)

- too bad for stellar evolution! (connection with GRBs?)

- In principle feasible for IMBH->MBH

- But one doesn't know how to compute waveforms

- Would be very interesting to constrain formation & growth history of IMBHs (and maybe distinguish between channels: pop 3 vs runaway merger of MS or compact stars)

- Stellar populations (IMF, SF history, metallicity)

- Difficult to say something if one doesn't assume some universality or simple galaxy-to-galaxy scaling. Only indirect constraints on models (for various channels).

- But extreme cases will be very telling (more WD/NSs than BHs, for instance)

Properties of high-mass objects (aka MBHs)

- Mass & spin “easy” to measure for each EMRI
 - Spin tells us about formation/growth
 - If high: mostly accretion (what fraction of mass, when?)
 - If low: more difficult to say (mergers, many accretion phases?)
 - Beware of bias: easier to detect prograde EMRI around fast spinning MBH (should be estimated)
 - Spin can in principle be measured through X-ray obs (iron line, QPOs?)
- Mass/spin function of MBHs
 - Should figure out the observational biases; feasible, at least in a relative way?
 - Personal comment: tidal disruption surveys may help constrain MF for low-M MBHs before LISA flies

Cosmology with I/EMRIs

- Doesn't constrain cosmological parameters better than other observations (e.g., CMB)
- Tells us something about galaxy merging in a range difficult to reach otherwise
 - EMRIs only detectable “locally” ($z \leq 1$); but may be significant evolution occurs in smallish galaxies over this period (constrain from low-L AGNs?)
 - IMRIs (and 2-MBH mergers) detectable very far ($z \sim 10$?); so could be very precious but:
 - Rates might be low because of inefficient dynamical friction
 - Can we be sure that the detected IMBHs haven't formed “in situ” through run-away collisions, etc? (redshift distribution? Spin?)
 - Would be useful to have “Davies plot”: accessible redshift vs M for various M_1/M_2 and plot MBH growth tracks in it

Testing GR and/or Kerr

- Cannot strictly test GR for lack of other grav. theory...
 - ...which is taken seriously
 - ...which deviates significantly from GR
 - ...for which inspiral/waveforms can be computed
- But test of GR is one of the main goal of LISA!!!

Testing GR and/or Kerr

- More pragmatic: test consistency of GR
 - If Kerr EMRIs detected (test multipole moments, PN parameters, horizon): GR+Kerr is fine
 - But 2-MBH mergers might be better suited for that (strong ring-down). However, those have (also) very uncertain rates
 - If some deviation is found (but detection feasible with Kerr templates), can start discussing non-Kerr objects (boson star) or grav theory with extra parameters (graviton mass)
 - What if no EMRI is detected (with Kerr templates)? Unlikely, the brightest events should be detectable even if rather weird.
 - Hmm... Still true if rate is 10/mission?

Testing GR and/or Kerr

- What about Kerr+perturbations (other star, disk)?
 - Cannot be mistaken for non-Kerr object such as boson star
 - Perturbation by other star very unlikely
 - Very few (<1) stars that close (if there is one initially, would have inspiralled long ago)
 - Duty cycle of order $t_{\text{insp}} \cdot \text{rate} < 1e4 * 1e-7$
 - Two EMRIs would have diverging a_1/a_2
 - Binary tight enough would have merged long ago (to be checked!)
 - Perturbation by accretion disk
 - Probably not detectable even for most extreme case (Eddington L)
 - Warning: if there is a disk, stellar objects might be in it => more effect
 - Only $>30\%$ of galaxies in LISA range are AGNs (right?)
 - Cannot prevent detection of EMRIs :-)... Use to study disks?
 - Can a disk change the stellar population by destroying giants?