# Supermassive black hole binaries

1. What is the next great advancement when it comes to theoretical models of supermassive black hole binaries (SBHBs)?

2. Can we have a self-consistent model for SMBH binaries, which follow their orbital decay self-consistently, including stellar physics, gas effects, disk instabilities?

3. Do SMBHs actually need to merge in a Hubble time, or is it only "us" who want them to merge?

4. EM signatures from binary SMBHs: periodic variability here is very likely one of the most robust predictions: how can we extract this signal from data (and be sure it's not "noise")?

5. By the time a SMBH merger occurs, will the galaxy still look disturbed?

6. We want to reconstruct the precessional dynamics from a BBH. If we assume a perfect waveform model, wiill the parameter estimation from LVC be good enough to determine the precessional dynamics? If yes, how good do the NR waveforms and BBH models need to be to enable this?

7. How well do we need to know about the BBH parameters, spin direction, spin orbit coupling etc, to do GW astronomy? What can you do if you just knew broad classifications, for example that the binary is precessing versus not precessing?

8. What do we expect the parameters (mass, …) of the BBH to be? What would surprise us?

9. Can we identify the recently-observed sinusoidal light curves of AGN as binary SMBHs? What is the precise reason of the variability?

10. How many confirmed EM detections of SBHBs are necessary to test theoretical models? How many confirmed GW detections of SBHBs are necessary to test theoretical models?

11. Although a variety of SBHB EM signatures have been predicted by theoretical studies, in practice, only a few approaches have been used to systematically search for binaries in observational campaigns. They rely on the simplest signature of binarity – the quasi-periodic variability caused by the orbital motion. We knew about this signature long before any theory was developed for SBHBs (since the stellar binaries were the “coolest thing” around). So what did we really learn from theoretical models / simulations of SBHBs?

## Supermassive black holes and accretion discs

1. Super-Eddington accretion onto massive black holes and/or seeds of MBHs:

    1. Is there any predicted observational signature?
    2. If so, do we expect to observe it? Or could it be too fast/too obscured?
    3. Could it be efficient in growing MBHs up to millions of Msun even at moderately low redshift (i.e. does the Soltan argument constrain super-Eddington growth below 10^8 Msun at all)?
    4. If so, what are the uncertainties on the predicted eLISA detection rates?

2. What do the broad line regions look like?

3. How does gas get delivered to the central SMBH through the gravitationally unstable regions of a self-gravitating disk?

4. Can we have extended episodes of super-Eddington growth (growing orders of magnitude in mass) to explain the z>6 quasar BHs - or is radiation and/or fragmentation of the collapsing gas a show stopper?

## GW and EM counterparts

1. What fraction of observable tidal disruption events will also be detectable in gravitational waves?

2. What will the expected frequency band be (for question 1)?

3. What is the best strategy for EM follow-up of GW candidates? How about coordinated observing of the sky amongst different groups that optimises sky coverage, spectral coverage (i.e. IR, Optical, X-ray, etc.) and temporal coverage?

4. The EM transient sky is very rich and identifying EM afterglows associated with GW triggers (not just binary inspirals) will be challenging. Is there any effort to develop common and shared data formats and software for analysing the transient sky?

5. For what mass ratios of NS-BH systems do we expect tidal disruption and EM afterglow? Is there any reason to suspect that BBH systems might have EM afterglows, even after many months or years? (For example, an old dormant disk might be rekindled by the black hole remnant that might receive a considerable kick after merger).

6. What is the expected luminosity of an off-axis GRB? To what distance could it be found with EM follow-up? What is the expected coincidence rate with advanced GW detections?

## Stellar-mass binaries

1. GW observations should help discriminate amongst different models of the formation and evolution of compact binaries. What are the discriminating aspects of the different models and how can GW observations use them?

2. What can we learn from 1, 10, 100 and 1000 events (mergers)?

3. What is the astrophysical impact of non-detection after 5 years of observing at design sensitivity?

4. How can one distinguish between dynamically formed stellar mass binaries and field binaries from inspiral? (from merger?).

5. What does the GW signature of a tidally disrupted neutron star look like?

6. What is the selection function of gravitational wave searches for compact binaries? Will it bias our conclusions about astrophysics?

7. What are the most easily constrainable features of binary evolution models?

8. If we knew the degree of alignment of spins in coalescing binaries, would it help to know the binary capture/formation mechanism? What about the eccentricity?

9. Are the even rates for double neutron stars significantly more uncertain than believed earlier (eg. from recent understanding of the selection effects in radio pulsar searches)?

10. If we measure that mass and spin function of black holes from GW observations what are the implications in astrophysics (and perhaps in cosmology)?

11. Could CW observations shed light on other methods (in addition to strong internal magnetic fields and “mountains") of sustaining ellipticity?

12. Are there good arguments to consider the distribution ellipticity the same for normal pulsars and millisecond pulsars?

13. Which are other good targets we could search for? Based on http://arxiv.org/pdf/1004.3558v2.pdf, could it be really worth to search for CWs from axions around a BH?

## Tidal Disruptions of Stars/ Tidal interactions

1. What is the next great advancement when it comes to theoretical models of tidal disruptions of stars?

2. During minor mergers, if the smaller galaxy has a 10^5 Msun black hole, will there be an increase in EMRI/tidal disruptions/plunges as the smaller galaxy is dissipated in the field stars of the larger galaxy?

3. What physics would need to be added in TDE simulations to convert accretion rates into luminosity?

4. Is G2 a star? How can we understand, at the same time, that it is surviving pericentre passage, while it seems to be part of a large “streamer” including at least another discrete cloud (G1) and a tail?

## Unclassificable (but/and good)

1. The GW community is obsessed with highly accurate GW templates. Is this level of accuracy necessary to answer the questions astronomers and astrophysicists would be interested having answers?

2. What constraint would a non-detection of an IMBH (in either ground- or space-based interferometers) place on their formation rate? (i.e. are event rates expected to be so small that a non-detection is expected?)