Suggested topics on exoplanets:

1. What is the origin of the radius valley? (W. Zhu)

a) The detection of a radius valley in exoplanets with close-in (<100 day) orbits has attracted lots of interest in the exoplanet community (Fulton et al. 2017). Many models have been proposed to explain the origin of the radius valley, among which two are leading: photoevaporation model (Owen & Wu 2017) and the core-powered mass loss mechanism (Ginzburg et al. 2018). These two models differ in several ways, such as the timescale and the dependence on stellar mass (e.g., Wu 2019, Gupta & Schlichting 2020). Attempts have been made to identify which one is most responsible for the observed features (e.g., Hirano et al. 2018, Berger et al. 2020). However, the answer remains unclear.

b) Issues suggested to cover:

    i. What are the key features of the radius valley? What was the key that led to its discovery?

    ii. How do the two models work? What are the key differences?

    iii. What did the observational tests say about the origin of the valley? What are the key issues in these tests?

2. What is the cause of spiral structures in protoplanetary disks? (X. Bai)

a) Recent high-resolution observations of protoplanetary disks reveal that many of them possess spiral structures. Some grand-design examples include disks around MWC 758 (Benisty et al. 2015, A&A, 578, L6) and SAO 206462 (Muto et al. 2012 ApJL, 748, L22, Garufi et al. 2013, A&A, 560, A105) at the near infrared, and Elias-27 (Perez et al. 2016, Science, 6307, 1519) at sub-mm together with more samples from the DSHARP survey (Huang et al. 2018, ApJL, 869, L43). The cause of the spirals is thought to be the result of either gravitational instability (e.g., Tomida et al. 2017, APJL, 835, L11) or interactions with companions (e.g., Dong et al. 2015, ApJL, 809, L5). It is yet to understood which or both of them are responsible for making spirals. One promising observational test is to measure the pattern speed (Ren et al. 2020, ApJL, 898, L38, Xie et al. 2021, ApJL, 906, L9).

b) Issues suggested to cover:
   i. What are the main observational characteristics of the spirals in protoplanetary disks?
   ii. What are the physical mechanisms behind the two scenarios, and what are their observational predictions?
   iii. What do the observational tests say about the origin of the spirals? What are the key issues in these tests?

Suggested topics on high energy astrophysics:

3. What is the nature of LB 1-like systems? (W. Zhu)

a) Liu et al. (2019, Nature, 575, 618) reported an interesting binary system, LB-1, and determined the mass of the companion to be ~70 M_sun, making it the most massive stellar-mass black hole found by then. This mass measurement was later challenged by other groups. Some argued that the companion should be a black hole with a much lower mass (e.g., Abdul-Masih et al. 2020, El-Badry & Quataert, 2020), whereas others argued that the companion might not be a black hole at all (e.g., Shenar et al. 2020). The ongoing search for Galactic black holes has yielded the discovery of a few other interesting systems, some of which suffer from similar issues in the mass determinations (see a brief summary in the introduction of Jayasinghe et al. 2022).

b) Issues suggested to cover:

    i. How are such systems detected? Why were they not detected before? What is the prospect of Galactic BH search in the next few years?

    ii. How is the mass of the companion measured/constrained? Where do the uncertainties come from?

    iii. What do BH “lower mass gap” and “upper mass gap” mean? What are the theoretical explanations for these mass gaps?

4. What is the origin of ultra-high energy cosmic rays? (X. Bai)

a) Ultra-high energy cosmic rays (UHECRs) are extremely energetic particles with energies beyond 10^18 eV. Where they are produced remains enigmatic, but for the most energetic UHECRs (approaching 10^20eV or beyond), their sources should be located within about 100Mpc due to the so-called GZK cutoff. In 2007, there was a Science paper (Abraham et al. 2007) claiming a correlation between their arrival directions with a few nearby active galaxies, but the results were quickly disputed. More solid evidence of anisotropy appeared after accumulating more data from the Telescope Array experiment (Abbasi et al. 2014) and the Auger collaboration (Aab et al. 2017), but the origin of the anisotropy remains unclear. Much of the latest results may be found in the recent review paper (Anchordoqui 2019, Physics Reports, 801, 1). Another avenue to resolve the puzzle will likely involve multi-messenger probes (e.g., neutrinos from IceCube).

b) Issues suggested to cover:

    i. How do we detect UHECRs? What pieces of information can we obtain by modeling the air shower? What are the uncertainties?
    ii. What are the likely source of UHECRs? Why do we expect them to be extragalactic? How do we distinguish different scenarios?
    iii. What are the prospects of unveiling the origin of UHECRs in the foreseeable future?

5. Origin of 511 keV gamma-ray emission from the galactic bulge. (H. Feng)

a) The galactic 511 keV gamma-ray line has been observed since 1970s, and was identified as the result of electron-positron annihilation; the origin of such positrons is still not clear. A variety of sources have been proposed, such as stellar nucleosynthesis products (Milne et al. 1999, ApJS, 124, 503; Kalemci et al. 2006, ApJL, 640, 55; Prantzos, et al. 2011, Rev. Mod. Phys. 83, 1001; Crocker et al. 2017, Nature Astronomy, 1, 135), gamma-ray burst (Casse, et al. 2004, ApJL, 602, 17; Bertone, et al. 2006, Phys. Lett. B 636, 20), pulsars (Guessoum, et al. 2006, AA, 457, 753), low-mass x-ray binaries (Bartels, et al. 2018, MNRAS, 480, 3826), neutron star mergers (Fuller et al. 2019, PRL, 122, 121101), as well as annihilations of MeV-scale dark matter particles (e.g., Hooper et al. 2008, PhRD, 77, 087302; Khalil et al. 2008, JCAP, 10, 024; Frey & Reid, 2013, PRD, 87, 103508; Farzan & Rajaee, 2017, JHEP 12, 083; Sabti, et al. 2020, JCAP, 01, 004) and even primordial black holes in the Milky Way (Frampton et al. 2005, Modern Physics Letters A, 20, 1573; Bambi et al. 2008, Physics Letters B, 670, 174; Keith et al. 2021, PRD, 104, 063033; Cai et al. 2021, JCAP, 03, 057).

b) Topics suggested to cover:

Describe the scientific background, current status of research on this issue, your preferred proposals.

Suggest topics on galaxies and cosmology:

6. 21cm absorption anomaly at cosmic dawn — new physics or systematics? (Yi Mao)

a) Bowman et al. (2018, Nature) claimed that the EDGES experiment detects an absorption profile centered at z~17 in the sky-averaged 21 cm spectrum. An absorption profile at cosmic dawn is usually predicted in theory (see, e.g., the review of Pritchard & Loeb 2012); however, the detected absorption amplitude of 500 mK is more than a factor of two (3.8σ) greater than the strongest possible absorption of 209 mK at this frequency under the standard picture. If the detection is correct, this anomaly must be explained either by some new physics (e.g., Barkana 2018), or by possible stronger radiation background than the CMB (Feng & Holder, 2018). Nevertheless, challenges have been posed for unknown systematics in the EDGES experiment — recent results of SARAS 3 experiment claimed that this anomaly is rejected at 95.3% confidence (Singh et al. 2021).

b) Issues suggested to cover:

   i. What is the physical origin of the 21cm signal at cosmic dawn? Why was the EDGES result surprising?

   ii. What are the leading explanations for the EDGES result? Why?

   iii. What to expect in the next decade on the detection of the 21cm signal at cosmic dawn?

7. Hubble constant from gravitational lensing time delay (S. Mao/D. Xu)

a) Based on the strong lensing time delay method, the H0LiCOW team measured the Hubble constant and reported a 2.4% precision (Wong et al. 2019). This is a key measurement that contributes to the so-called "Hubble tension" between early universe and late universe measurements. However, others have claimed that the H0LiCOW measurements may have substantially underestimated uncertainty due to the overly simplified lens model (e.g., Kochanek 2020). Studies that have better treatment of the lens model report Hubble constant that is in better agreement with early universe measurement (e.g., Birrer et al. 2020).

b) Issues suggested to cover:

   i. How to measure Hubble constant via strong lensing time delay? What are the key observations that are needed?
   ii. What are the key assumptions in the modeling? How realistic are they? Which ones could have potentially caused non-negligible (however unclaimed) systematic errors?
   iii. Why the earlier and later time-delay measurements have resulted in significantly different values of Hubble constant?
   iv. How better can TD method constrain the Hubble constant in the

next ~10 years?

8. Why has fuzzy dark matter started gaining popularity over cold dark matter in the past decade? (D. Xu)

a) Fuzzy dark matter is a fairly new idea, centered on the idea of dark matter being composed of ultralight bosonic particles. Axions has been one of the most promising candidates. An axion is a hypothetical elementary particle introduced to resolve the strong CP problem in quantum chromodynamics (QCD). If axions exist and have low mass within a specific range, they are of interest as a possible component of cold dark matter (Armengaud et al. 2017, MNRAS, 471, 4606; Hui et al. 2017, PRD, 95, 043541; Banik, et al. 2021, JCAP, 2021, 043; Hayashi et al. 2021, ApJL, 912, 3; Hui et al. 2021, ARAA, 59, 42).

b) Topics suggested to cover:

   i. What is the particle origin of fuzzy dark matter? What astrophysical observations has fuzzy dark matter managed to explain? Why has it become competitive with cold dark matter?

   ii. What are current observations that put constraints to fuzzy dark matter models?

   iii. What are smoking-gun observations predicted by fuzzy dark matter theory?