Summary

Shude Mao
Jodrell Bank Centre for Astrophysics
History of gravitational lensing

• Histories of lensing
  – Carswell gave a fascinating account of the first discovery of gravitational lens
    • The care taken to rule out binary quasar scenario from velocity differences
    • Lack of interactions with theorists
  – Massey’s talk highlighted
    • Eddington’s careful design of the experiments
    • blogging
  – Many discoveries were due to Refsdal (Saha)
  – Theorists are too skeptical?
Microlensing

- Galactic microlensing (Gould & Beaulieu):
  - Discovery of 14 extrasolar planets in a different part of parameter space beyond the snowline
  - SuperEarths are very common
  - Parallax+finite source size effect can be used to discover brown dwarfs and black holes
  - Korea Microlensing network can potentially increase the discovery rate by order(s) of magnitude
  - In the long term, Euclid may probe the planets down to Earth planets; complementary to dark energy surveys
  - Rotation effects in gravitational microlensing (Penny)

- Cosmological microlensing (review by Wambsganss, Sluse, Bate [poster])
  - it can be used to constrain the fraction of mass in stars
  - Spectro-photometric observations of 2237+0305 (39 spectra), $R \sim \lambda^{1.2}$ (Sluse)
  - broad band colour (Bate)
  - More examples (J1131-1231) to follow
Strong gravitational lensing

• SLACS (koopmans, Czoske)
  – Discovery of ~100 new lenses
  – Lensing + dynamics, X-ray weak lensing
  – IFU (17 on VLT, 13 on KECK): isothermal (Czoske), within $R_{\text{eff}}$, 27% is DM
  – Lensing-stellar population synthesis (Leier et al. poster)

• Substructures (Xu+Virgo, Bryan)
  – Too few subhaloes (too further out)
  – Too many satellite galaxies (CLASS unusual)
  – **Galaxy-galaxy lensing may be more promising in the future**

• Nature telescopes
  – The highest-redshift discovery of water masers at $z=2.64$ in J0414+0534 (McKean, 25 more systems being monitored)
  – Study of a LBG at $z=2.73$, SFR~40 Msolar/year (Volino)

• “New” lenses
  – COSMOS field (70 new lenses, COSMOS 5921+0638, Anguita)
  – MUSCLES (2 new lenses, UKIDSS/SDSS, Jackson)
  – AT20G (radio survey), 20 Ghz survey, 2 new candidates (Chhetri)
  – New microlensing candidates (M31, Darnley)

• Future surveys (panStarrs, LSST, SKA etc.)
Weak lensing

• Review (andy Taylor)
  – 3D tomography, dark energy
  – Can be used to constrain the neutrino mass (0.03 eV<\Sigma m<0.5 eV, Tereno)
  – Cosmic shear (CFHTLS, 57 square degrees)

• Intrinsic alignment (Bridle):
  – How are galaxies associated with DM?

• Locuss
  – c~8.45 vs. c~4.96, but large scatter (Smith);
    lensing~SZ~x-ray (~20% level); A1689 (c=15->9)
  – Constrain substructures (Hamilton-Morris): cluster vs. galaxy scales.
Weak lensing

• Cluster lensing (review, kneib, CCCP: hoektra)
  – Hundreds of lensing clusters (RCS, CFHT-LS, SDSS, MAC, and X-ray)
  – Impressive models of A2218, A1689, …. (vs. galaxy)
  – Stellar dynamics + X-ray+ lensing: concentration
    • Center determination? LSS?

• X-ray underluminous clusters? (Dietrich)
  – Group to poor clusters
  – Impact on constraint on sigma8?

• Major surveys to come (CFHTLS, PS1, …….)
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  – solve the magnification problem (E is conserved)
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