将来計画とサイエンス
惑星形成と惑星探査
コメント

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注：「2010年代の光赤外天文学」サイエンス（2005年3月）の議論も思い出そう
• When and how do planets form?
  - disk accretion phase?
  - core-accretion or gravitational instability or else?
• How diverse are planetary system architectures?
  - where do planets form? Or orbital evolution?
  - are Solar-system-like planets favored (in original)?
  - are planets in habitable zones common or rare?
  - environmental effects?
• Can we observe extra-solar planets directly?
  - can we determine atmospheric structure and chemistry?
  - can we detect signatures of life?
• How do stellar mass are determined?
• How do binaries and clusters from?
• What is the role of magnetic fields in star formation?

Just to discuss the first 3 items due to limited time.
What we know
- Young low-mass brown dwarfs do exist around 1 Myr star. <VLT/Subaru/HST>
- Not sure about young planets yet! <ANY>
- Inner gap around 1 Myr stars. <Spitzer>
- Asymmetric dust distribution around ~100 Myr stars (Vega-like stars). <HST>

Key observations
- probing accretion disks surrounding young stars and searching for tidal gaps diagnostic of forming planets
- searching for gaps in Vega-like disks around main-sequence stars
- determining accurate ages for star-disk systems

Key facilities
- ALMA
- ELT
- SPICA/J WST
What we know
- Disk morphology is diverse. <Subaru/HST>
- Disk mineralogy is diverse. <Spitzer>
- Planets are diverse. <since Mayor/Queloz>

Key observations
- Various indirect observations (Doppler, Transit)
- Statistical studies of dust distributions
- Precise measurements of reflex motions:
  - continuation of current radial velocity programs
  - precise proper motion measurements

Key facilities
- Specialized small telescopes?
- SPICA/J WST
- ELT
- GAIA/J ASMI NE?
惑星は直接検出できるか？

• What we know
  – All in indirect ways.
  – Thermal emission detected. <Spitzer>

• Key observations
  – Imaging and spectroscopy

• Key theoretical work
  – how to diagnose life from spectroscopic signatures?

• Key facilities
  – high contrast imaging & spectroscopy telescopes
    • coronagraphs that block out light from central star
      – use on current and future ground-based telescopes with ExAO
      – TPF/Darwin/JTPF
まとめ

• 星惑星系形成研究は多様な切り口がある
• 惑星検出研究は単一目的
• すばる
  - 専門化と一般性のバランスを保つ
  - 特長（広い視野と綺麗なPSF）を生かす
  - 機動性：旬の装置を生かす重点観測を
  - 開発の裾野：必要不可欠な装置アップグレードを見極めて必要な投資を

• 地上とスペース（いろいろ思うところはありますが結論だけ）
  - どちらも必要
  - ELTは是非ハワイに
  - SPICAはJWSTと同じくらいの時期に
  - 地球型系外惑星の検出と特徴付けにはTPFが不可欠