SKA and the Cradle of Life

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Addressing BIG Questions!

• How do planets like the Earth form?

• How did life originate?

• Is there intelligent life in the Galaxy?
Cradle of Life ‘Cycle’

Planets in the Universe

Pre-Biotic Molecules

Extra-terrestrial civilizations

Exo-planet Characterisation

SKA — Square Kilometre Array
Grain Growth

- Difficulty in growing grains through cm-sized regime
- Need cm-wave observations to probe cm-sized grains, emission is weak
State-of-the-art

Shallow spectral index indicates grain growth in AS209 (Pérez et al. 2012)
Inside the snow line with SKA1

- Need ‘planet traps’ to help grains grow
- E.g. the snow/ice line

Hasegawa & Pudritz (2012)

Spatial resolution at 12 GHz at 100 pc
Proto-planetary disc simulations

- Disc simulation from Laura Perez based on Isella et al. (2009)
- Imaged with latest SKA1-mid configuration by Tyler Bourke
- 1 M☉ star with MMSN 0.01 M☉ disk inclined at 45°
- Distance of 125 pc
- 0.037" beam at 12.5 GHz
- 1000 hr integration

12.5 GHz intensity
Low-mass jets and discs

NICMOS

WFPC2

HH111
VLA 8 GHz
Rodriguez et al. (2008)

DG Tau A  e-MERLIN 5 GHz Ainsworth et al. (2013)
Jets in Massive Young Stars

Cep A2 (Patel et al. 2005)

Methanol maser polarization giving 3D B field (Vlemmings et al. 2010)
e-MERLIN Pathfinding

- Same 0.04 arcsec resolution as SKA1-mid
- PEBBLES Legacy project (PI Greaves) will explore PPDs
- MSF (PI Hoare) MYSOs
- YSO Jets (co-I Richer)
- Adding Goonhilly to e-MERLIN will enable better imaging of equatorial targets and joint studies with ALMA

Heywood et al. 2011 arXiv1103.1214
Pre-biotic molecules

- Simple amino acids are detectable in pre-stellar cores and proto-planetary discs
- Cold regions where cometary ices form, less line confusion
- UK astro-chemistry expertise

Jimenez-Serra et al.
Single deep pointing – big return!

Grain growth

Pre-biotic molecules

Tens of targets

Methyl carbamate $N = 1.0 \times 10^{12}$ cm$^{-2}$, $\Delta v = 3.0$ km s$^{-1}$

6D tomography

Magnetic flaring

Jets
Exo-planet characterization

- Low-frequency (~50 MHz) bursts seen from Jovian planets
  → Planetary magnetic field, rotation period, tilt of magnetic axis, exo-moons?
- UK magnetospheric and exo-planet expertise
• Sensitivity of SKA1 could detect
  • Planetary Radar out to 1 kpc in single 0.1 Hz resolution integrations
  • Terrestrial airport radars out to 10 pc
Telescope that will reveal secrets of the heavens

2020... know if the date we’ll finally anybody’s out there

By Sun Professor Brian Cox

2,500 radio dishes on SKA
One headquarters in Britain
Ten countries working together

1 million aerals in use
1 billion galaxies to be mapped
£1.2 billion cost of project

Huge scope... how the dishes would look and, inset left, locations of sites
• Known exoplanets, but ...
• RV
• GAIA
• TESS, PLATO

• Nearby stars now...
• GAIA
Summary

• SKA1 can do high impact science in the Cradle of Life area:
• Study grain growth in rocky planet zone
• Search for pre-biotic molecules
• Characterize planetary magnetic fields
• Targeted searches for intelligent life
• Jets and disc winds in star formation
• The kind of impact that will help SKA1 and 2 get funded
• UK in good position to use e-MERLIN to its advantage