Title: Cosmology 4

Date: Jun 09, 2006 11:00 AM

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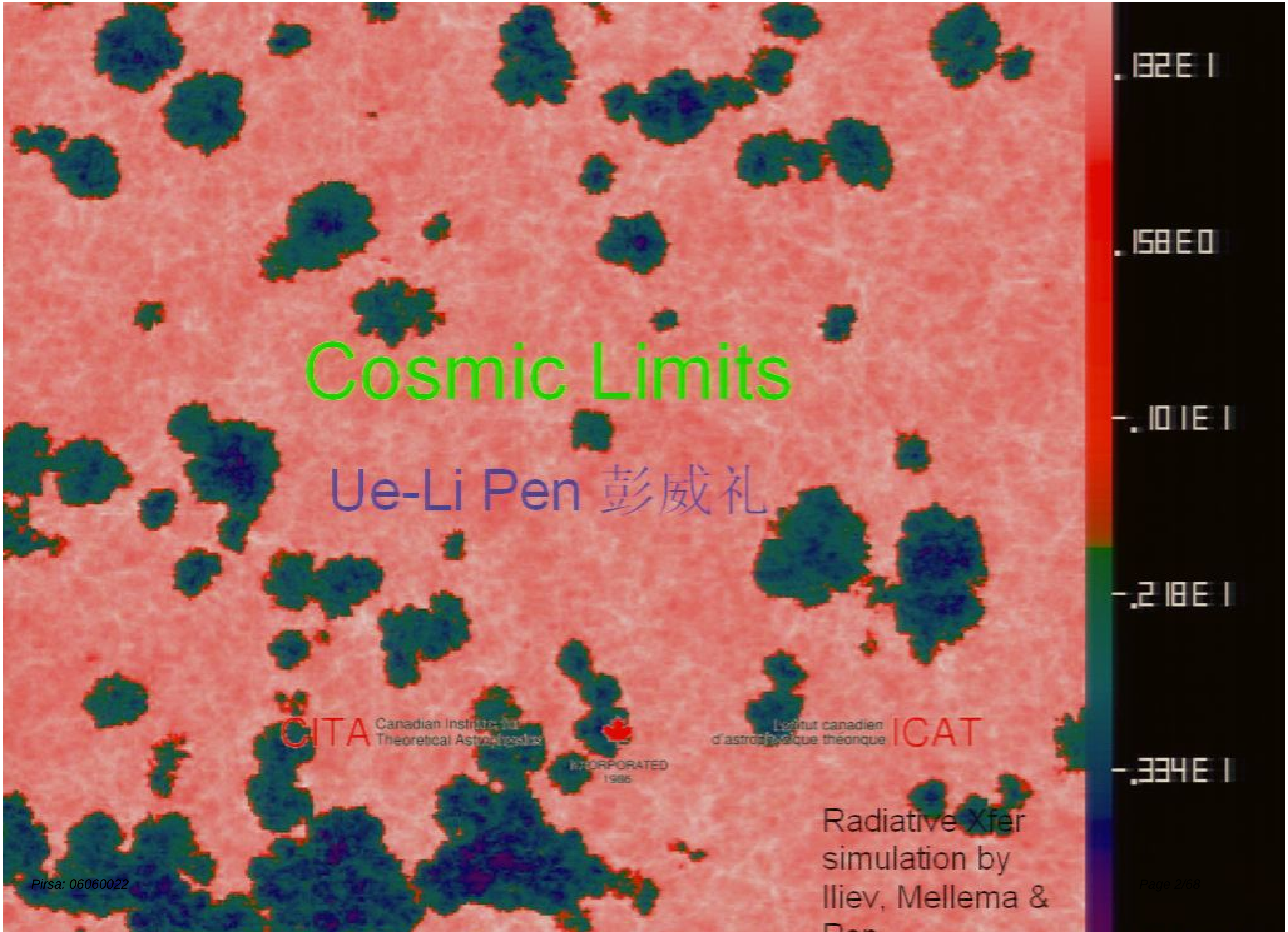
Abstract:

Cosmic Limits

Ue-Li Pen 彭威礼



CITA Canadian Institute for Theoretical Astrophysics

INCORPORATED 1986

Institut canadien d'astrophysique théorique ICAT

Radiative Xfer simulation by Iliev, Mellema & Pen

Limits to Cosmology

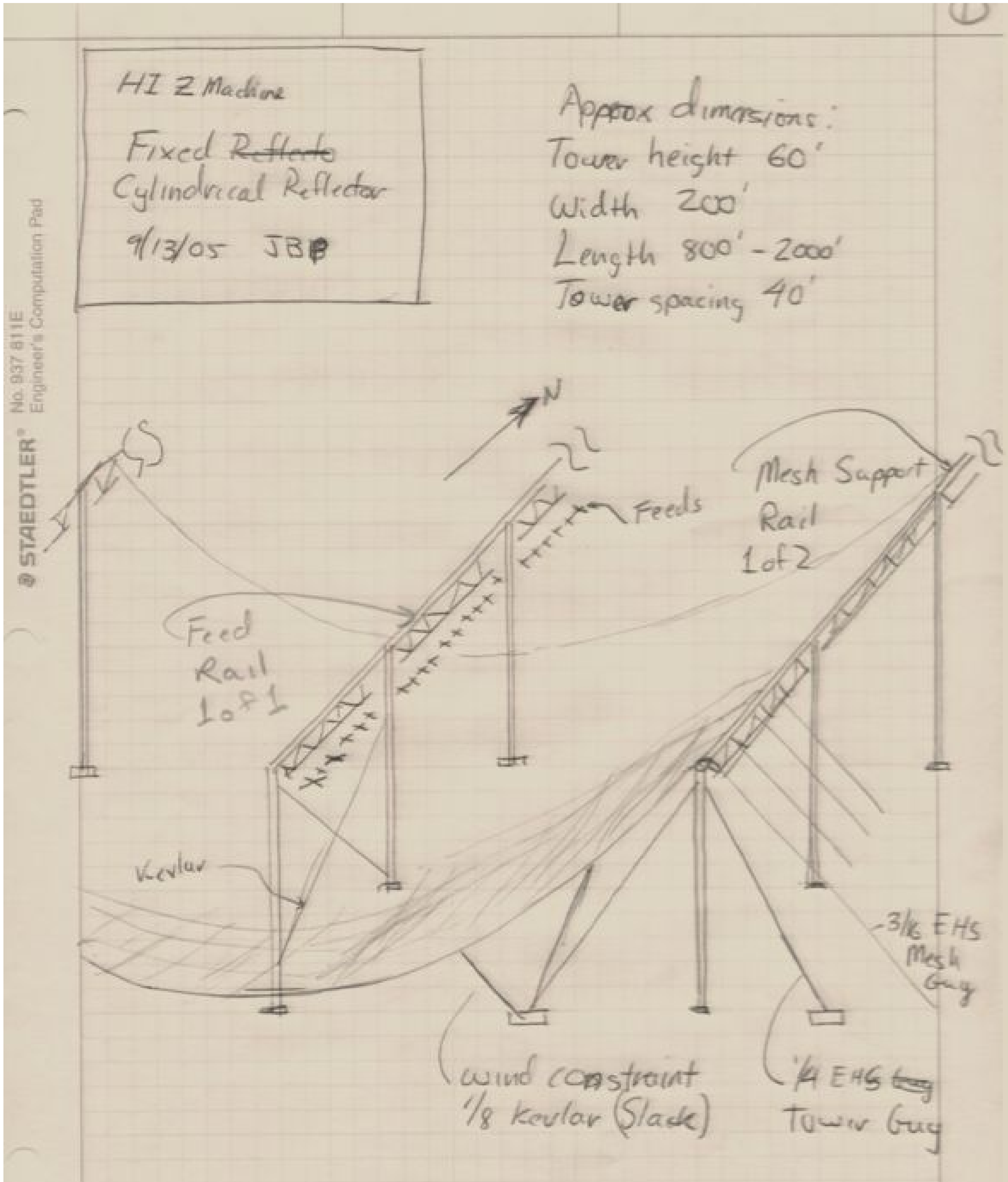
- CMB, lensing, galaxy survey: Power spectra sample variance (cosmic variance).
- For CMB, statistical accuracy ~ $1/l_{max}$, -> parameter errors > 10^{-3}
- Other methods (SNe, clusters) in progress, accuracy unlikely higher, except possibly CMB polarization.
- Of theoretical interest: 2nd order PT, gravity waves, precision equation of state
- Can such accuracy be achieved observationally?

Telescope Capability

- For mapping: need large number of galaxies with redshifts: $>10^8$
- Possibilities: optical spectra, HI 21cm (KAOS, SKA)
- Costs estimated at $\$10^{8-9}$
- Unconventional creative experiments: EoR, HSHS
- Two observational windows: $z<2$ (baryon oscillations) and $z>6$ (EoR)

Molonglo, Australia

Ooty, India



Transit Cylindrical reflectors use suspended mesh, with a line of feed points: no moving parts, low cost: ~$\$10^7$

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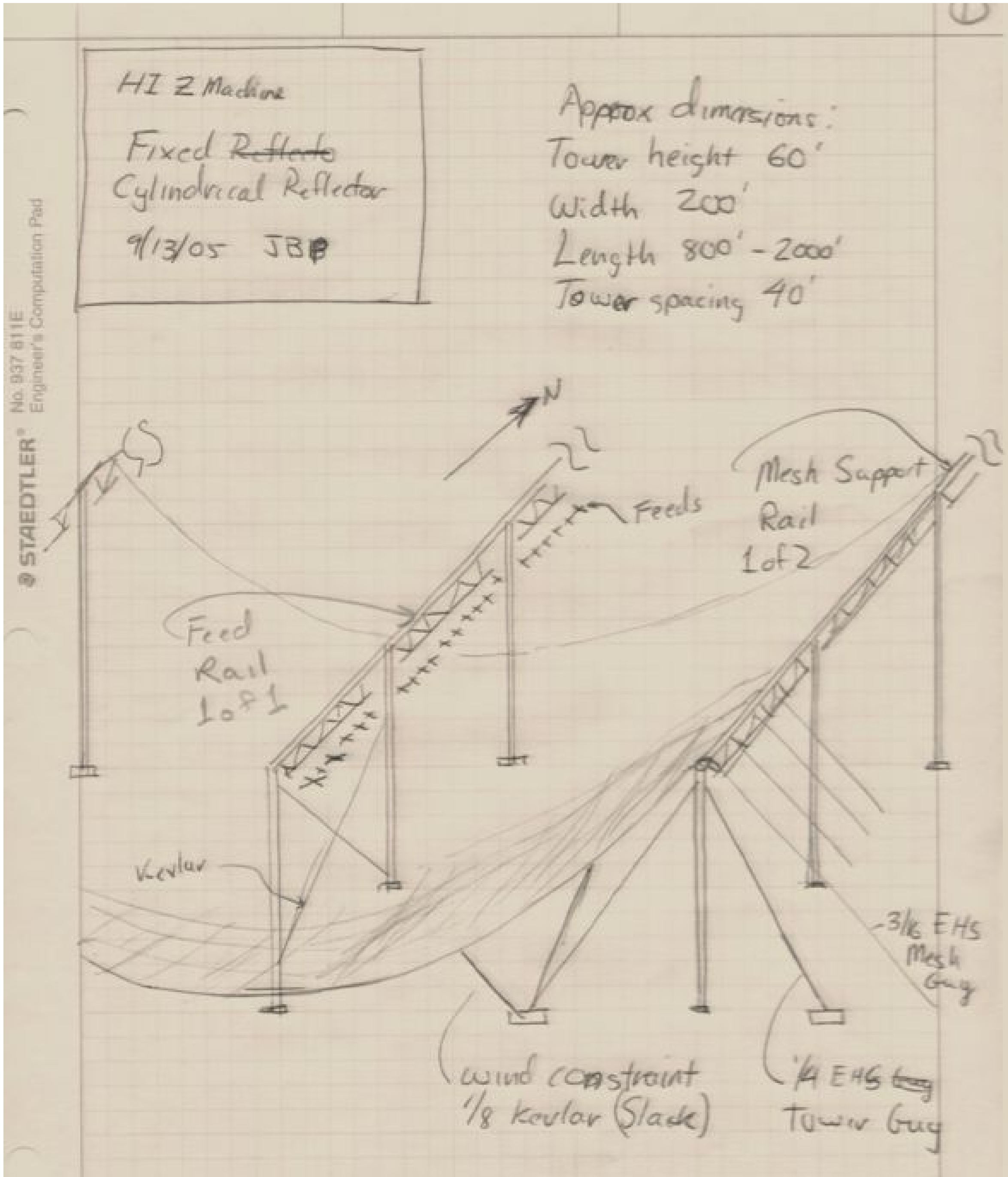

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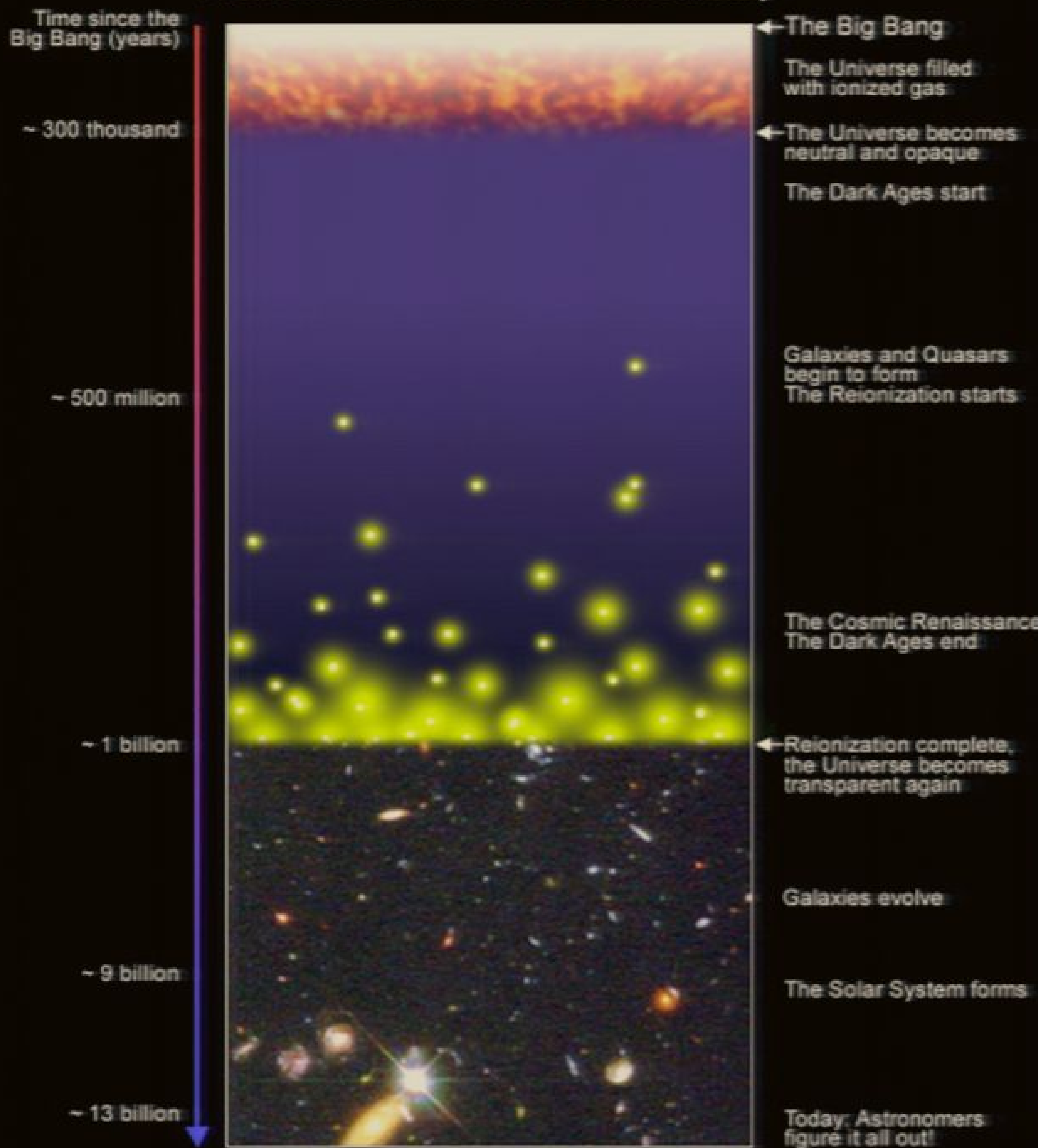
Hubble Sphere HI Survey: HSHS

- Concept by Jeff Peterson *et al*, astro-ph/0606104
- 21cm galaxies: all sky, $z<2$, 10^8 redshifts
- Baryon oscillations, weak lensing
- static wire mesh cylinders, transit telescope, $A \sim 10^5$ m^2, FOV~100 deg^2, res~1"
- Cell phone technology: cheap low noise receivers. But need quiet site.
- N log N correlation cost, interferometry w/multiple cylinders
- ~ 2 orders of magnitude cheaper than SKA
- Prototype construction sponsored by U. Seljak in progress at CMU

What is the Reionization Era?

A Schematic Outline of the Cosmic History



Computational Cosmology

ce@thevarsity.ca

SCIENCE

Thursday, March 6, 2003 7

Super computer does astronomy super-fast

J of T astrophysicists will use Canada's fastest computer to simulate the universe

ROSEMARY McNAUGHTON

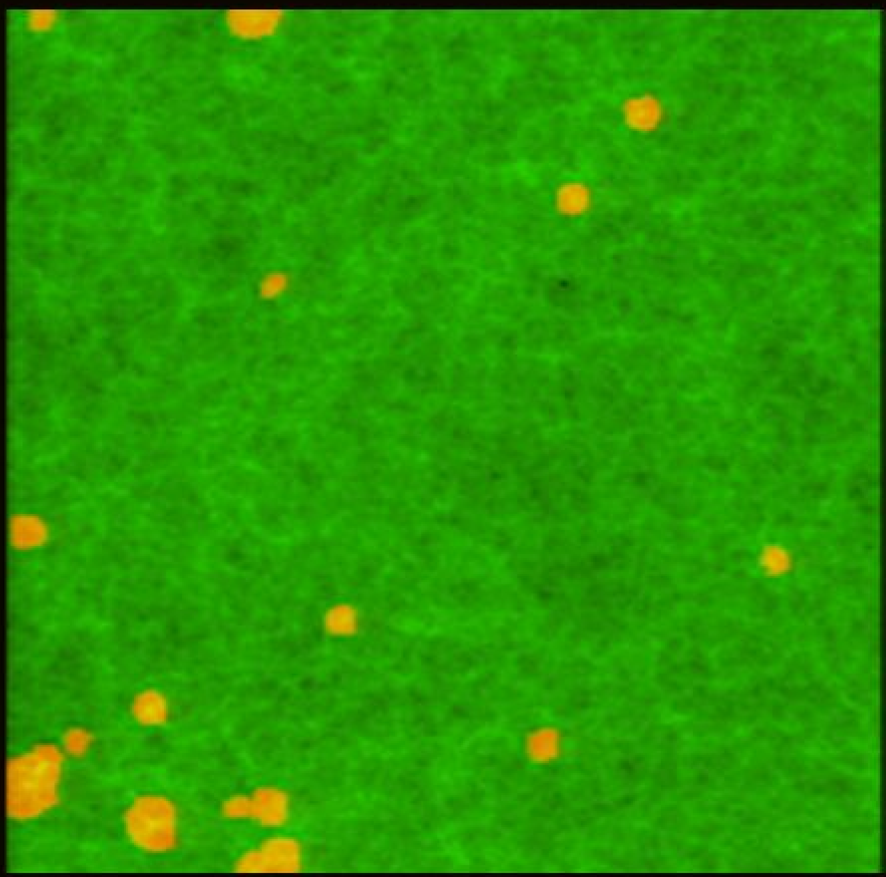
supercomputer named after a
uple of hosers is ready to take off
U of T.
McKenzie, named after the icon-
Canadian duo, has 256 two-pro-
ssor motherboards that together
rform 1.2 trillion floating-point
erations per second.
To put this in perspective, if you
uld borrow the brains of your
ighbours for a second, you'd
ed to get each of the 5 million
idents of the GTA to compute
0,000 calculations per second to
ep pace with the supercomputer.
This new 512-processor cluster
re at U of T now tops the com-
ting power of the High Perfor-
nce Computing Virtual Labora-
y housed at Queen's University.
d while the HPCVL supports
earch in a variety of disciplines
m psychology to engineering,
s cluster is entirely dedicated
astrophysics. It will tackle some
the most complex problems
astronomy today, like galaxy
rgers, black hole accretion,
d the production of the cosmic
crowave background after the
liest stages of the formation of
universe.
Resear[...]rtment
astronomy and astrophysics
f the Canadian Institute for
eoretical Astrophysics (CITA)

Ue-Li Pen stands in front of McKenzie, Canada's fastest supercomputer. Each of the five million people in the GTA would have to perform 240,000 calculations per second to keep up.

- Computational efforts at CITA:
- Implemented Canada's highest ranked academic computer (2002)
- Upgrade through SciNet
- Algorithm & Code developments
- N-body, MHD, CMB
- SNe, BH, WL, GC

Reionization

- First objects:
- 21cm @ z=6-25
- 50-200 Mhz
- ΔT = 23 mK,
- ~ μ Jy- mJy
- Angular scale $5' < \Theta < 30'$, freq res 500 khz
- Challenging theory



z=19-12 simulation, Iliev, Mellema, Pen 2005. 1° FOV

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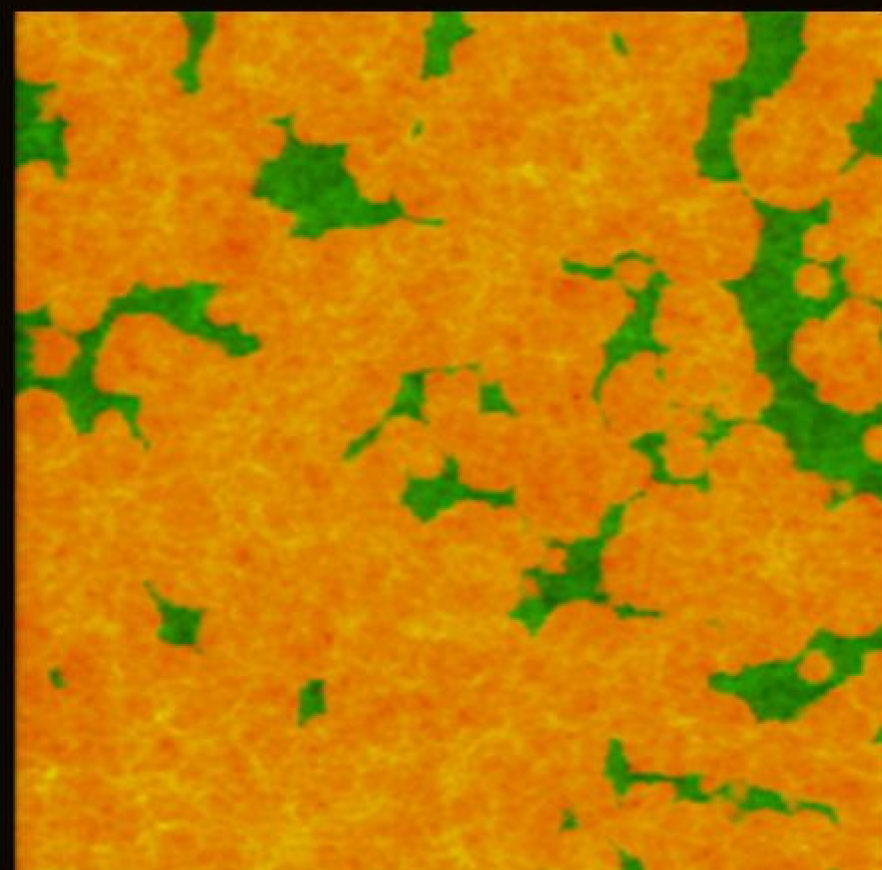

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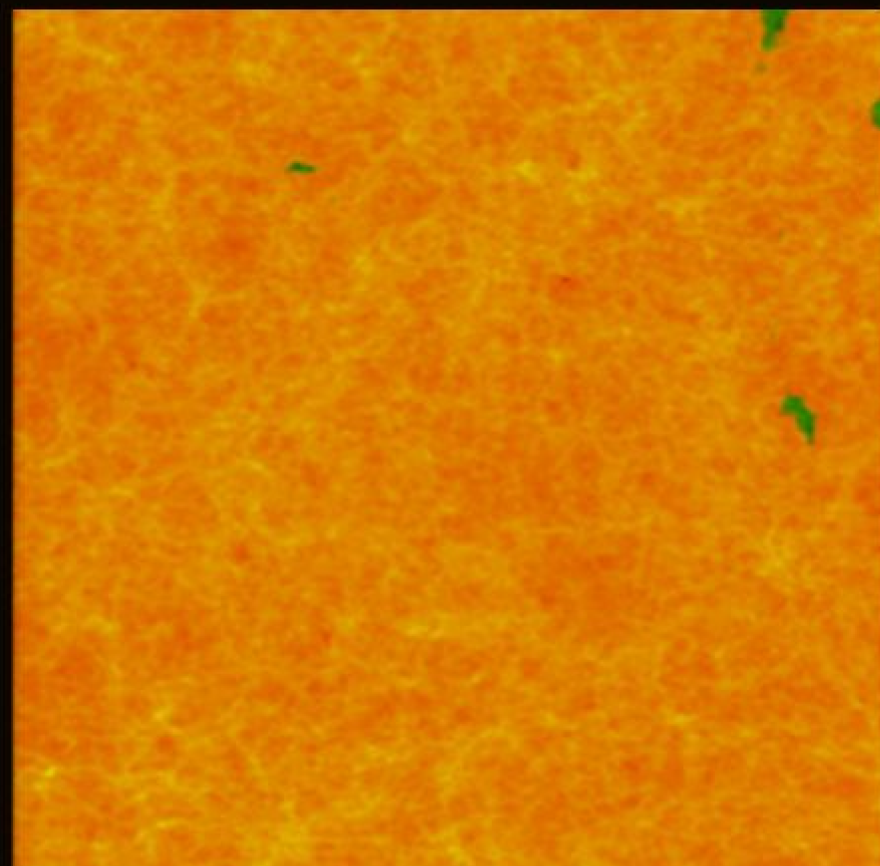

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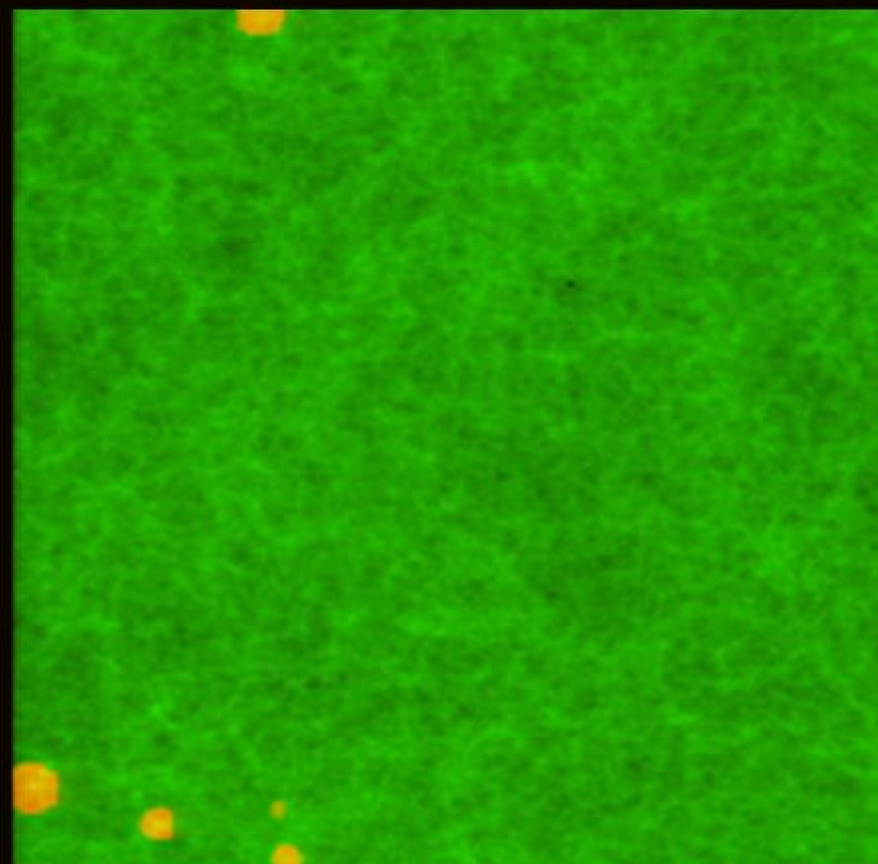

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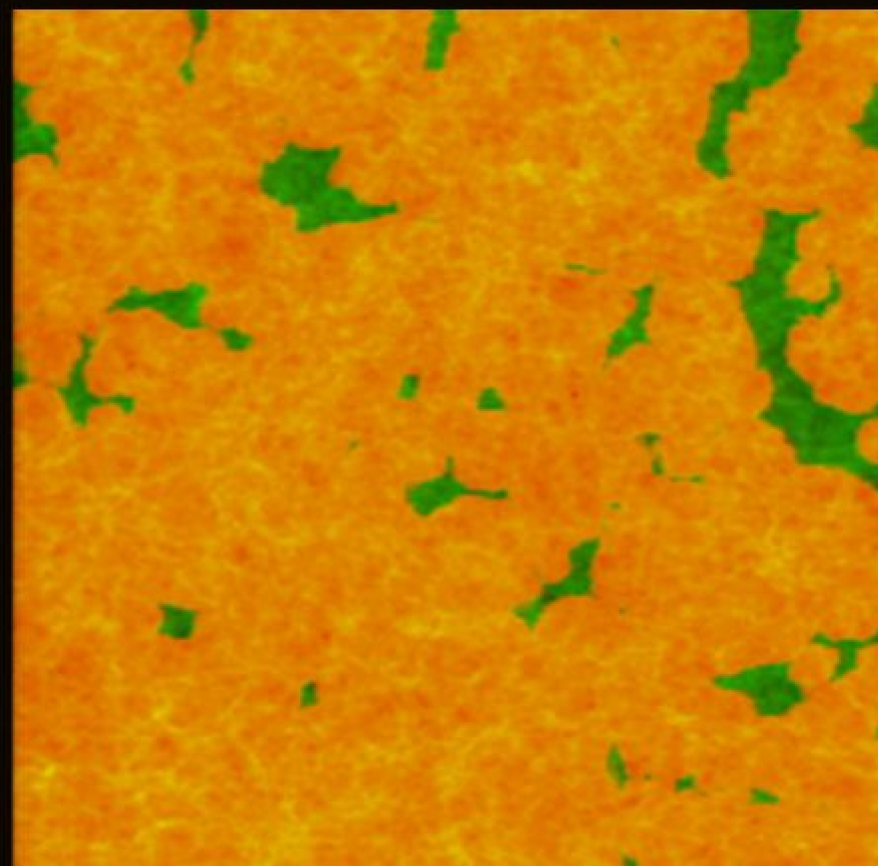

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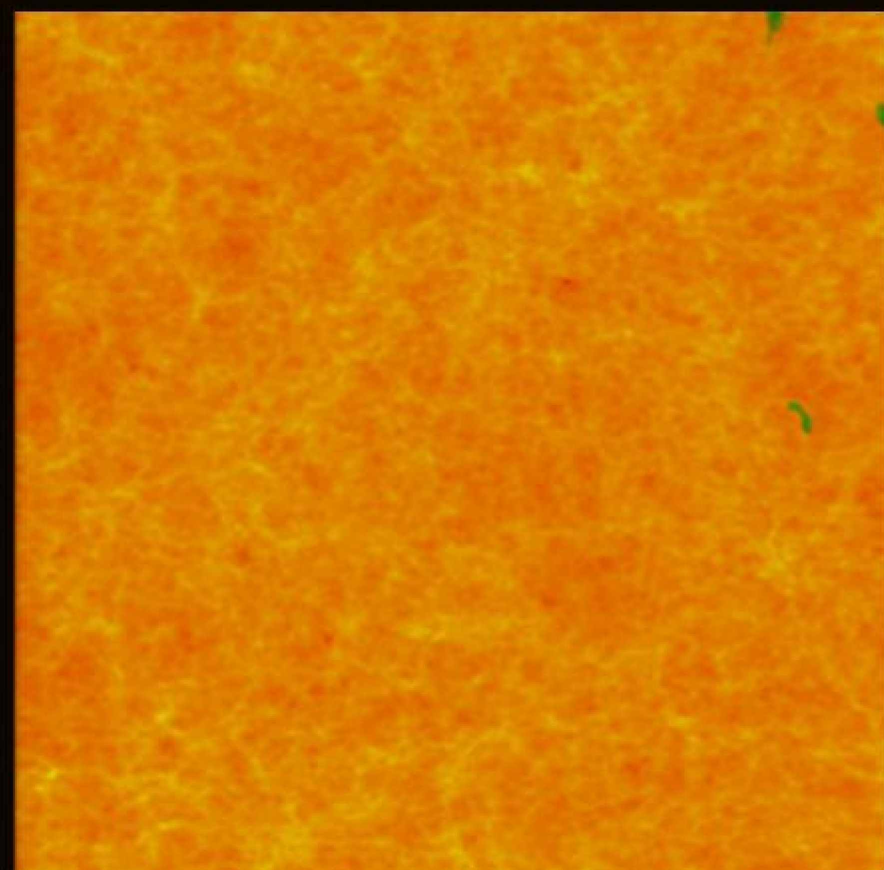

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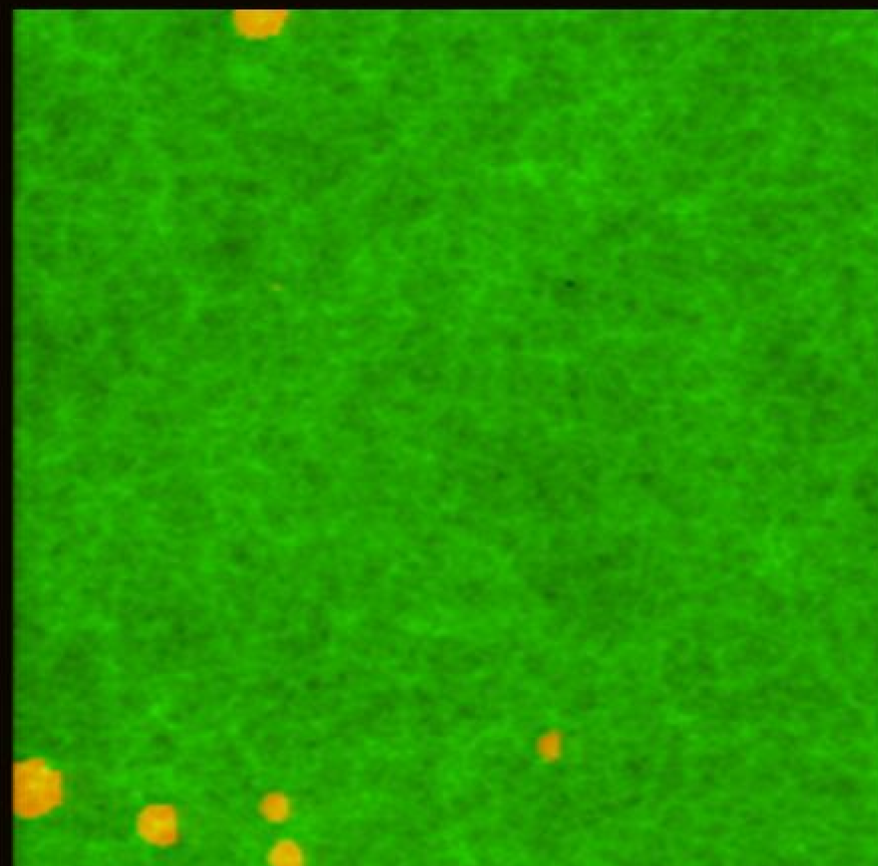

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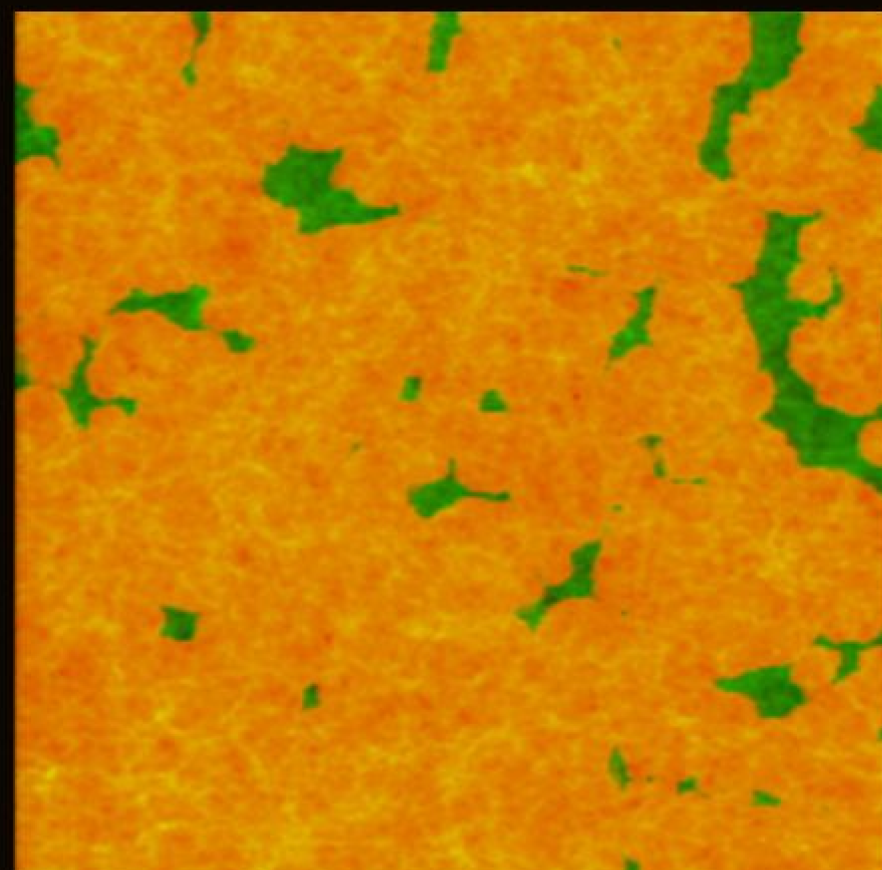

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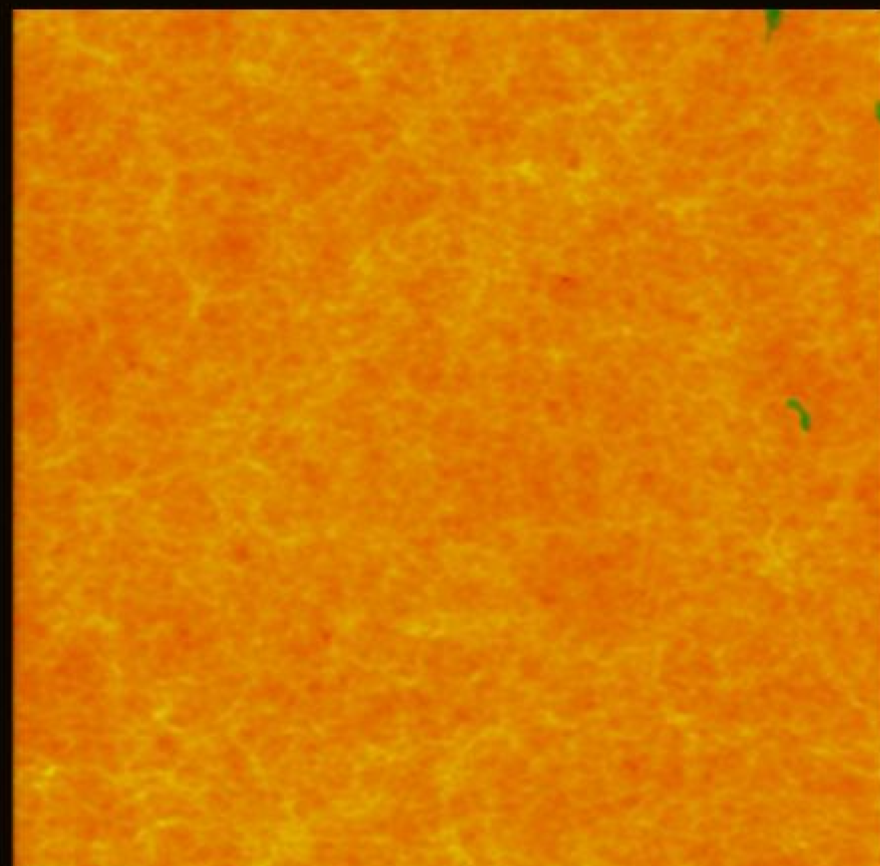

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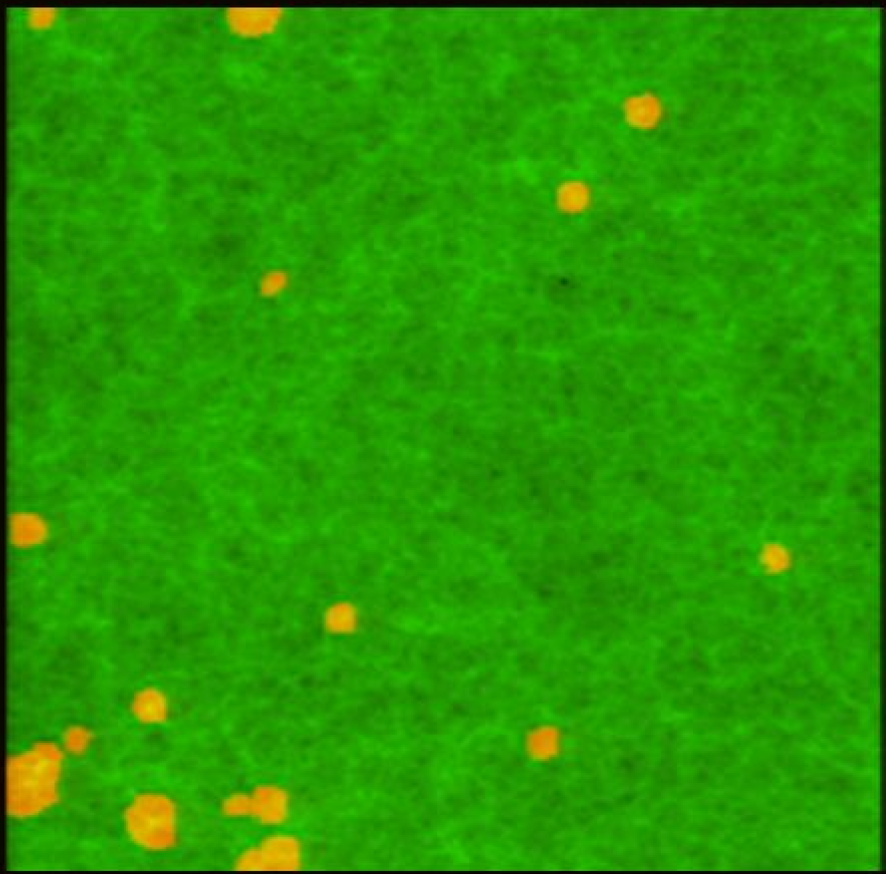

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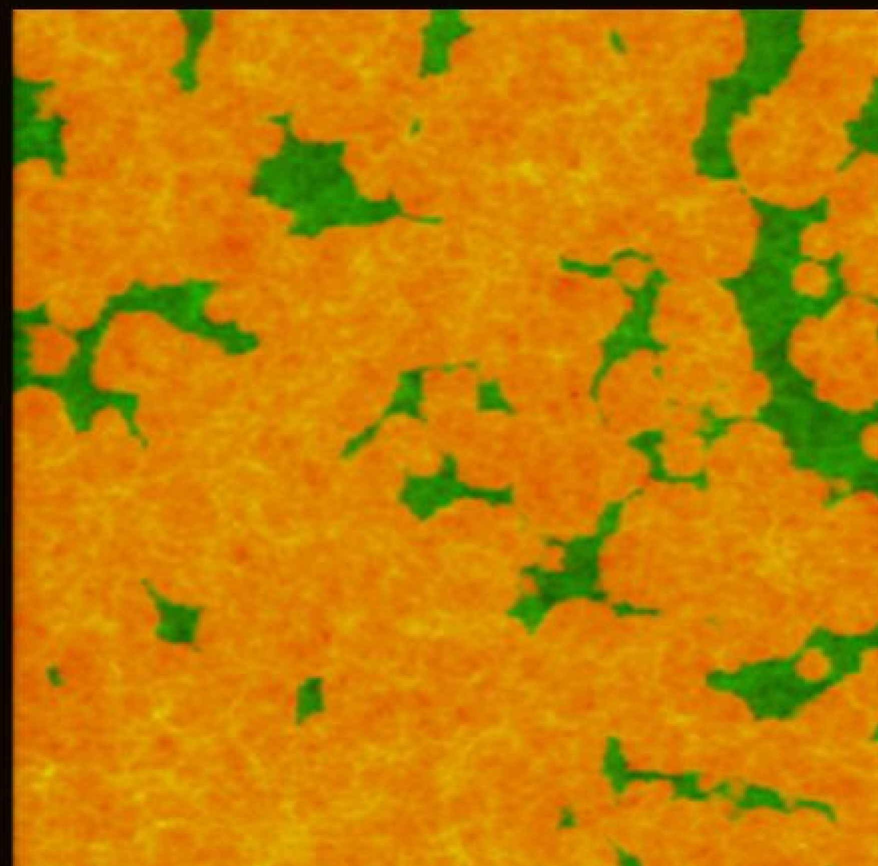

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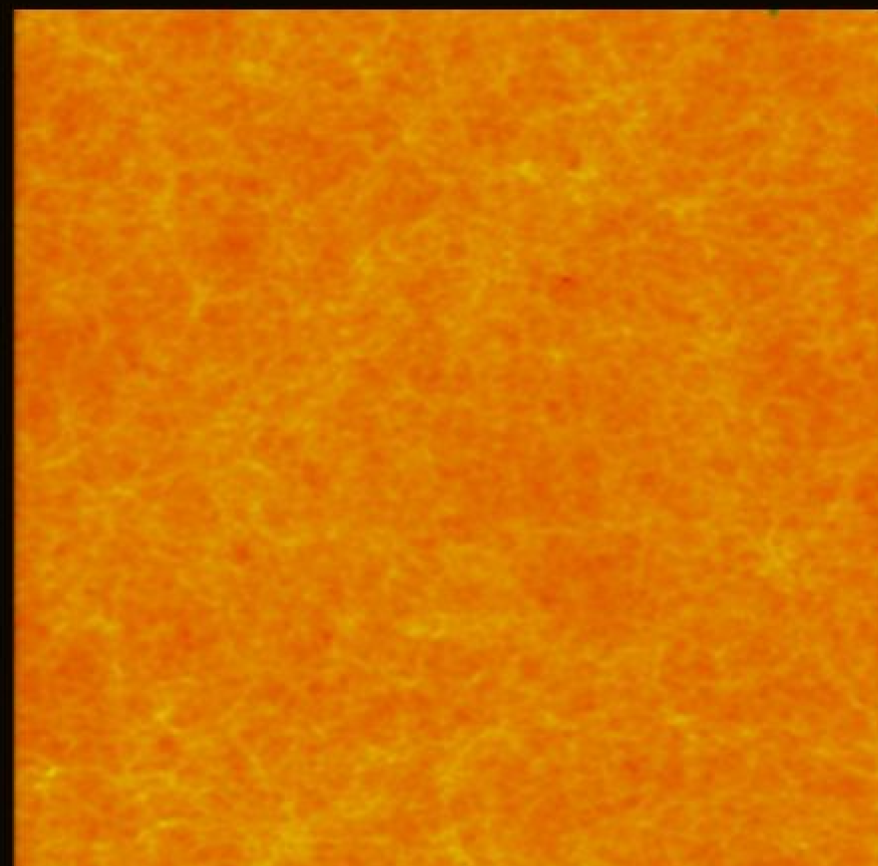

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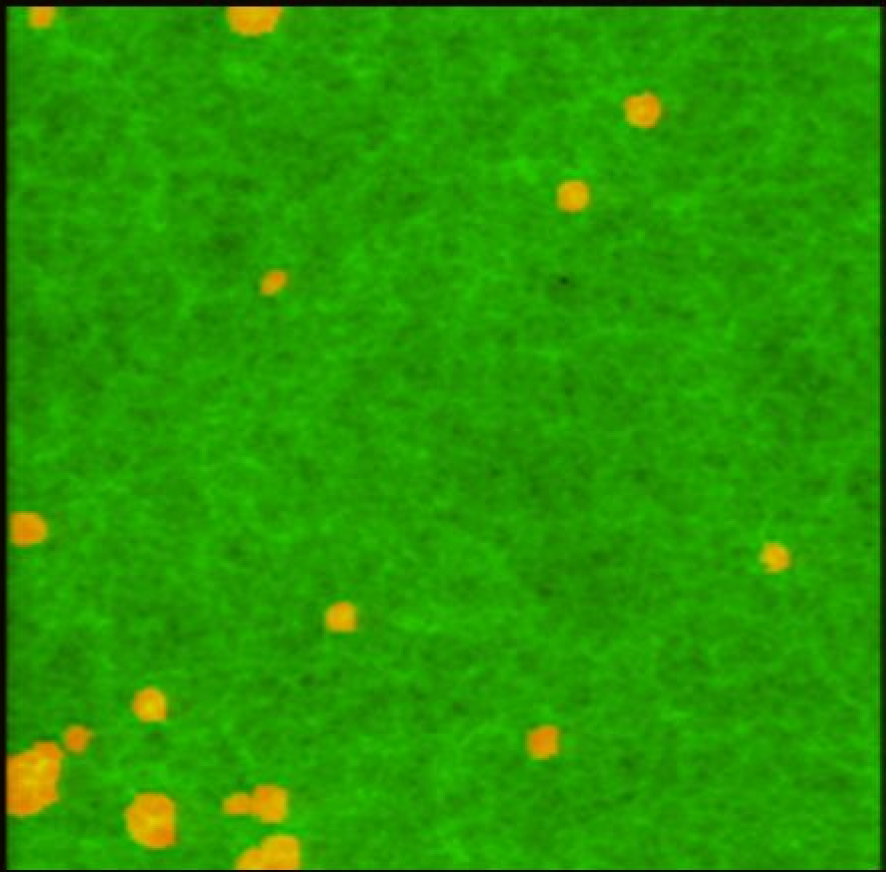

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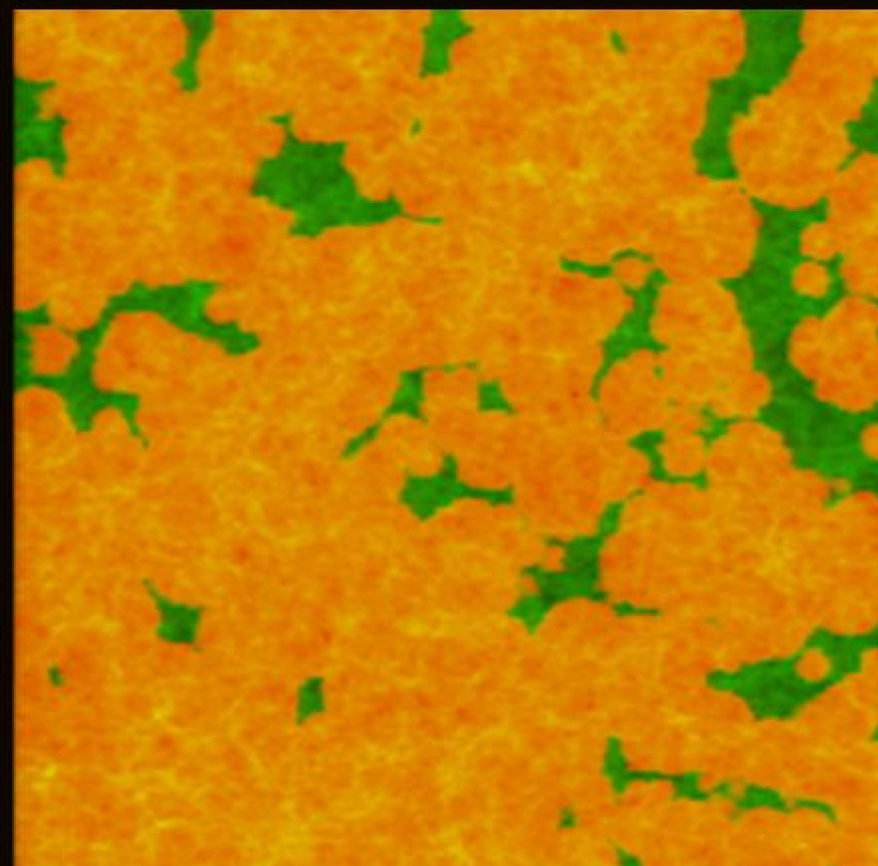

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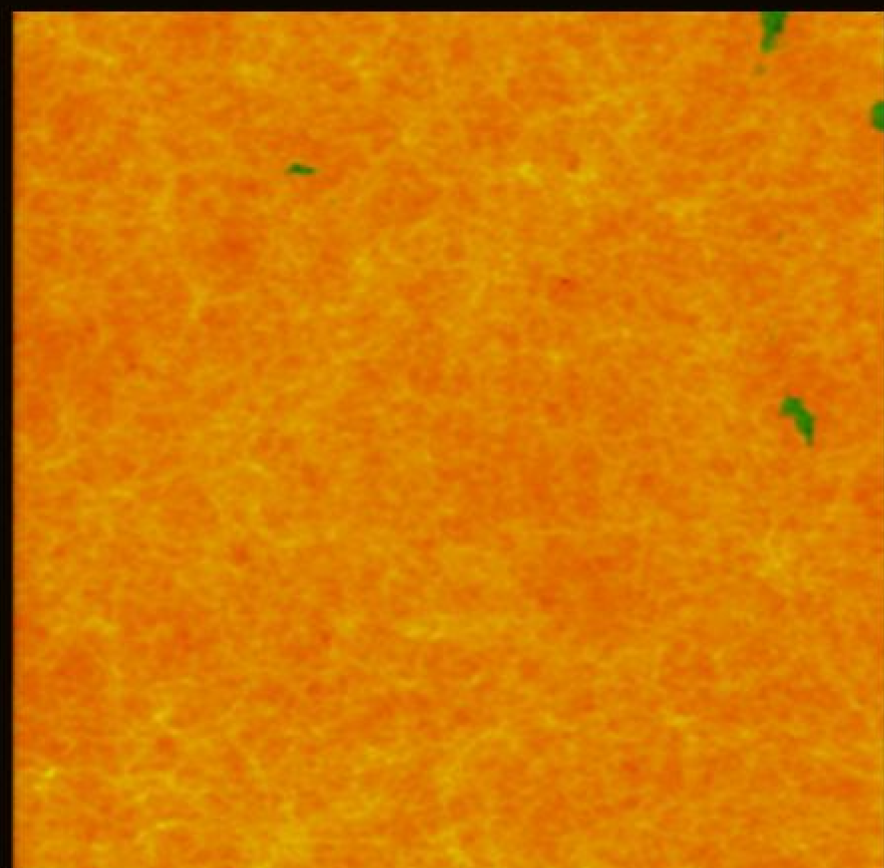

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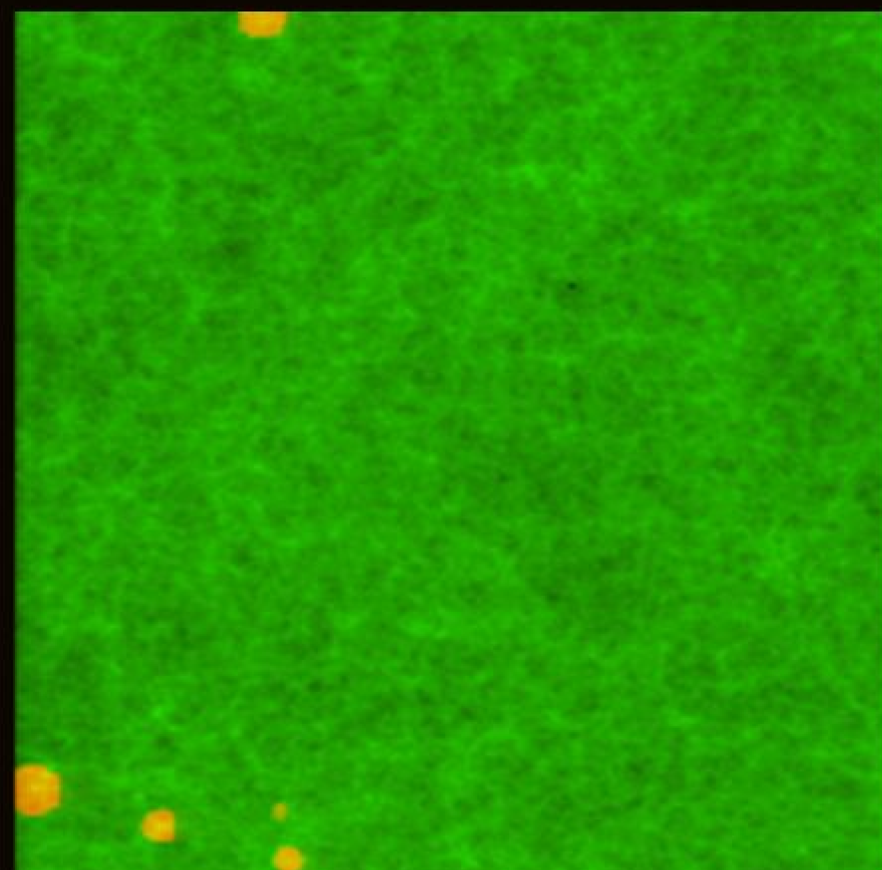

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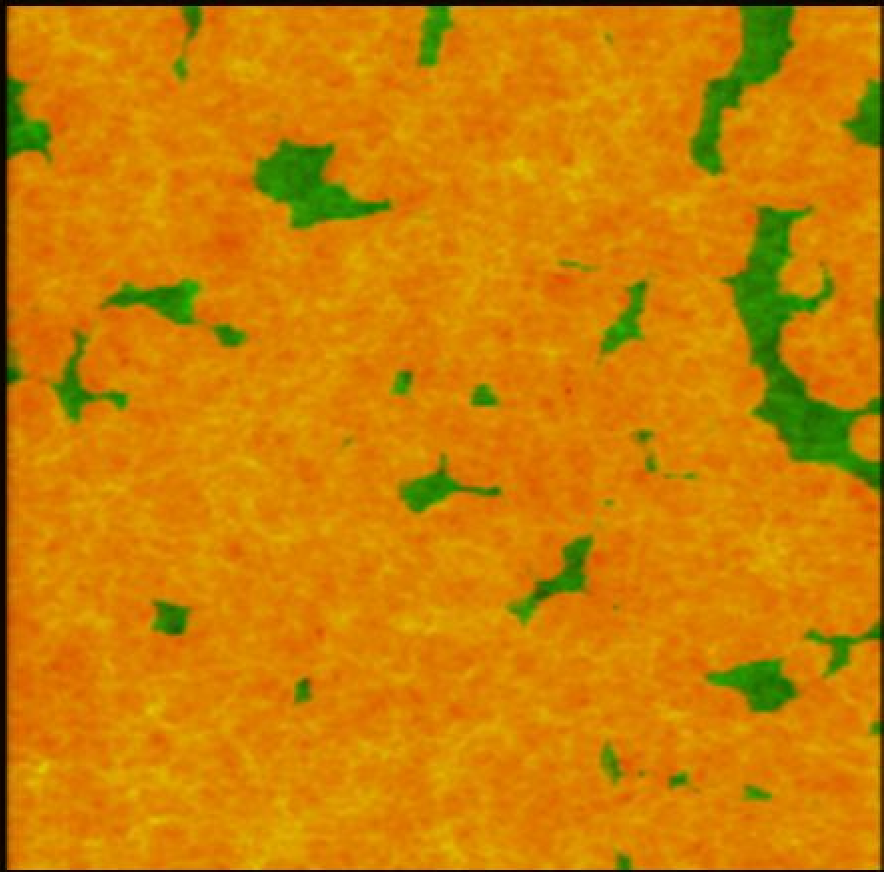

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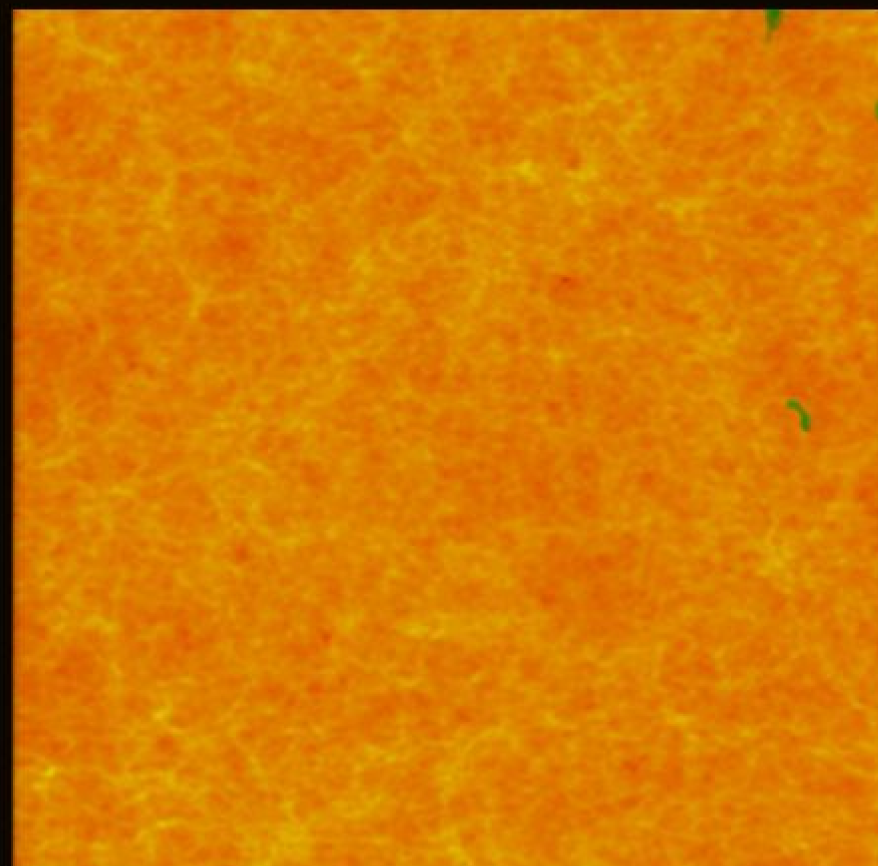

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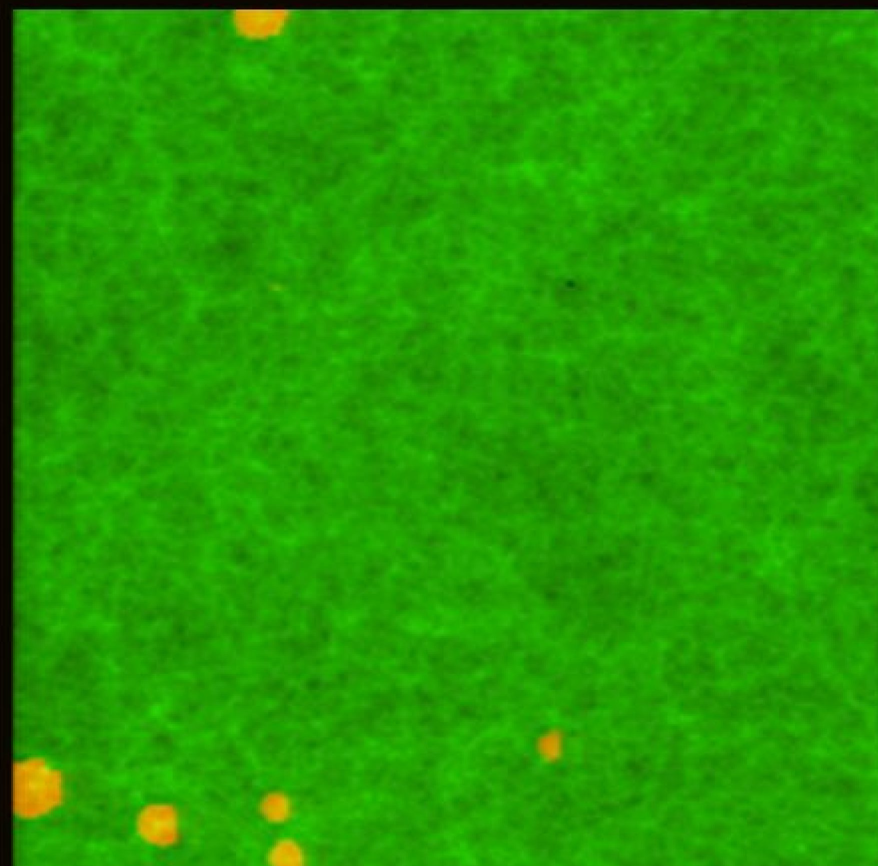

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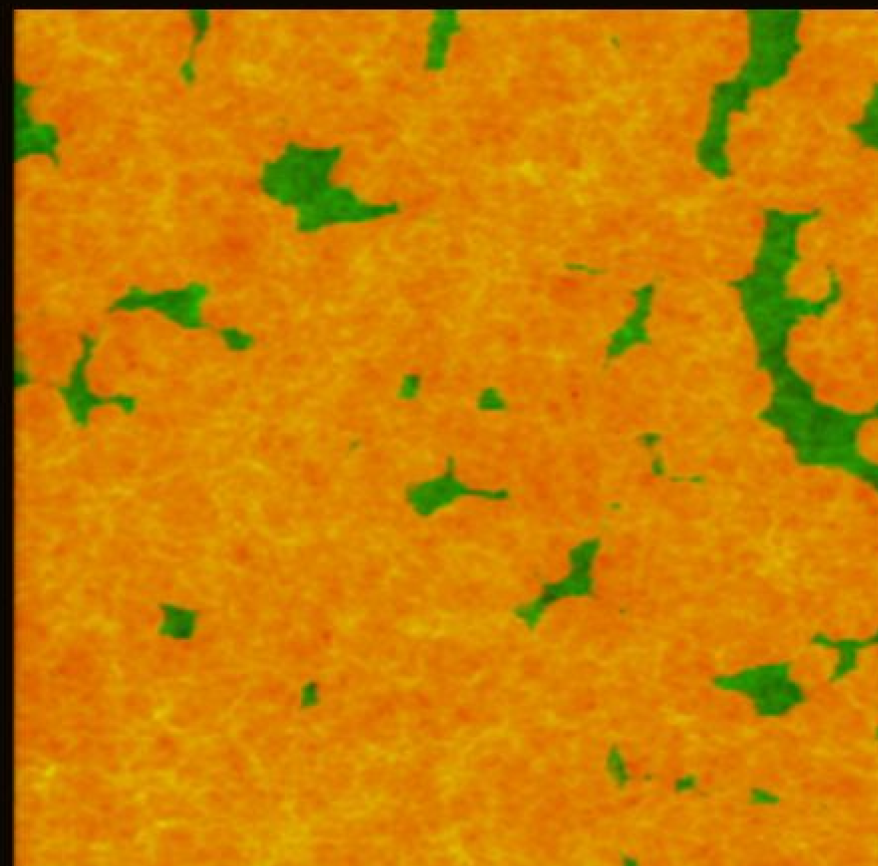

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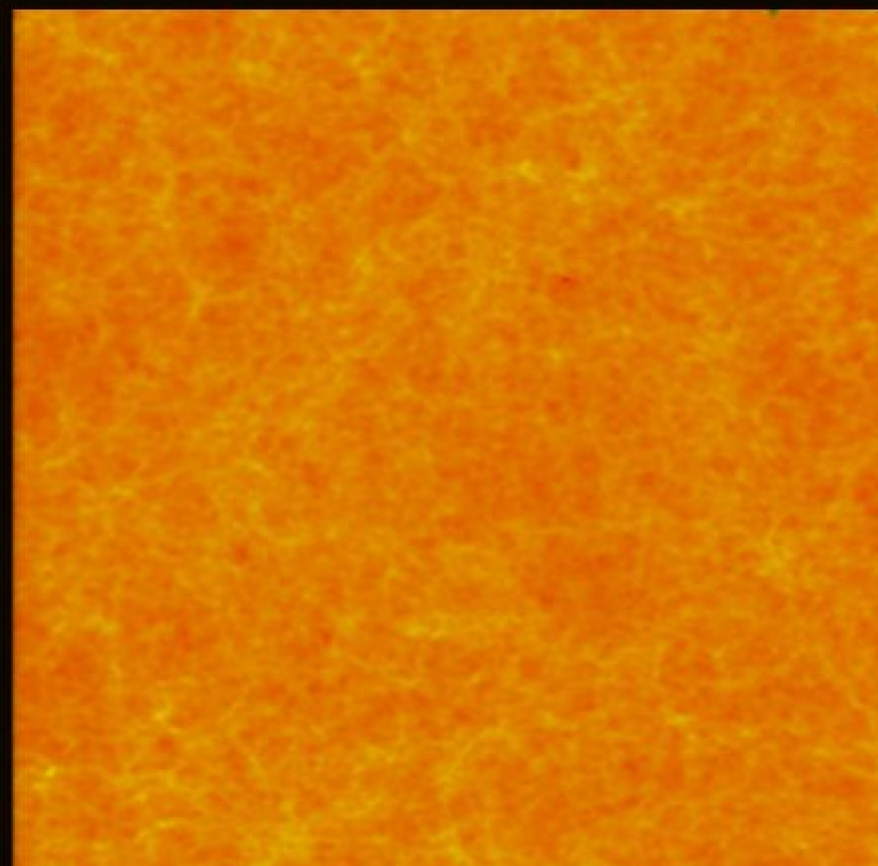

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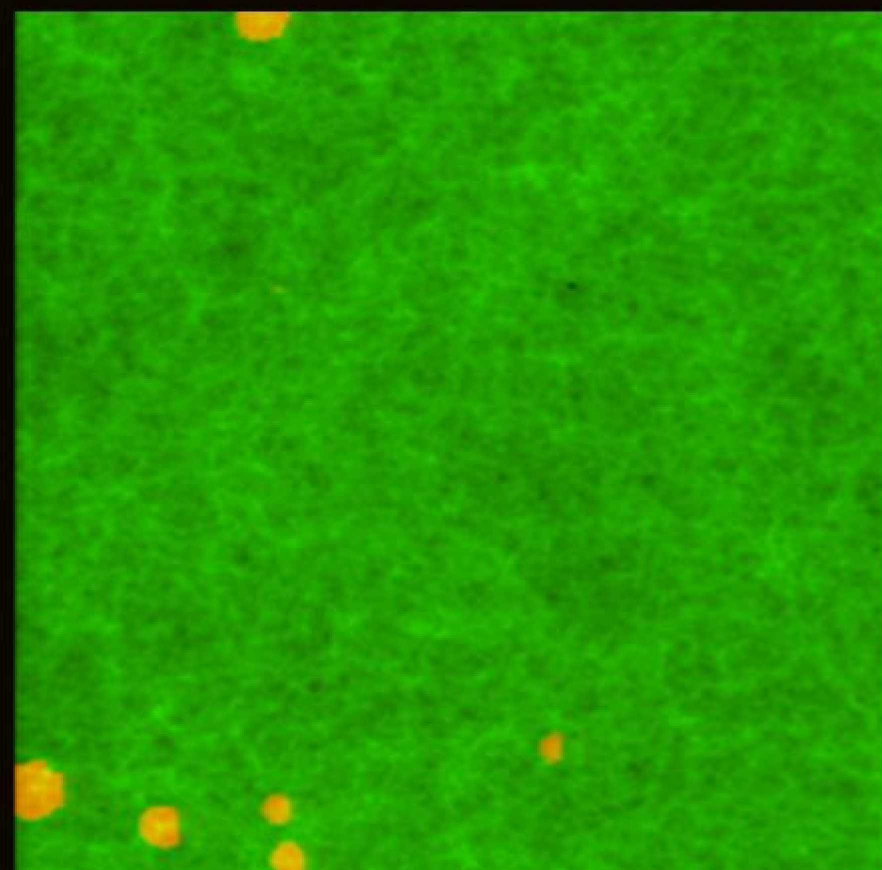

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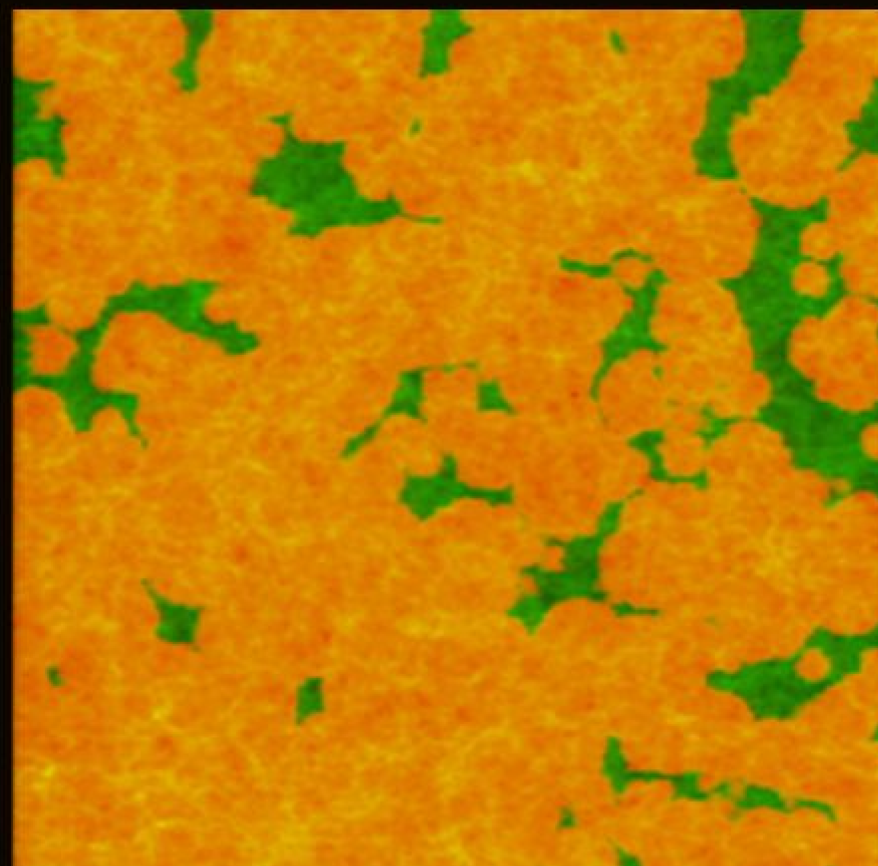

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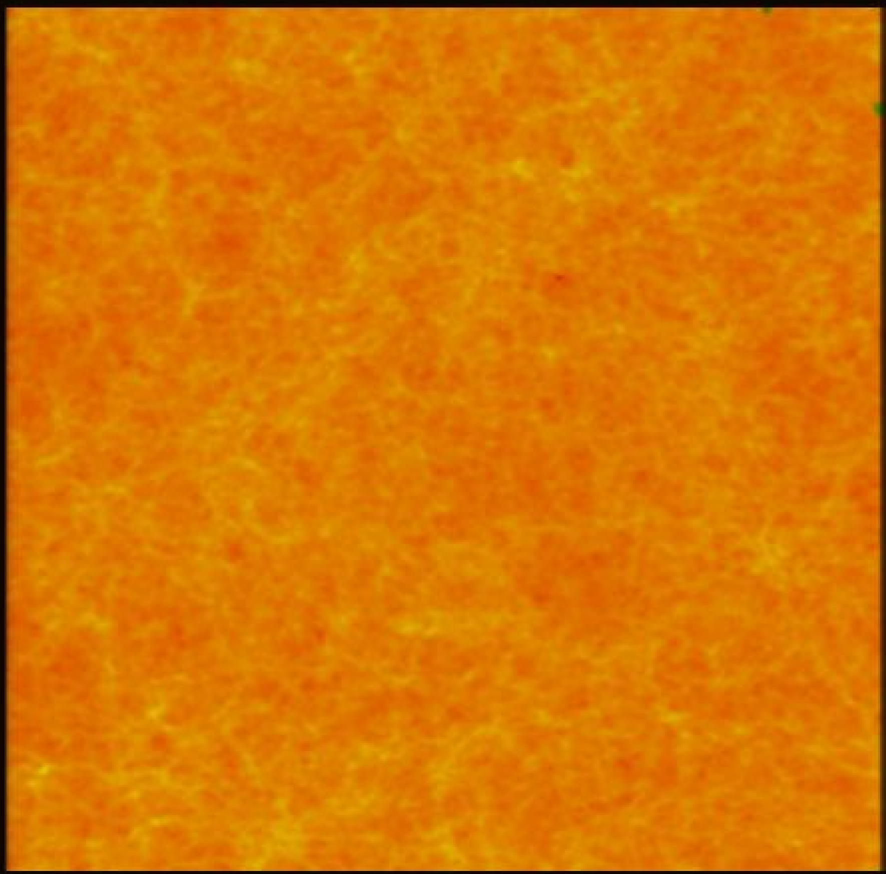

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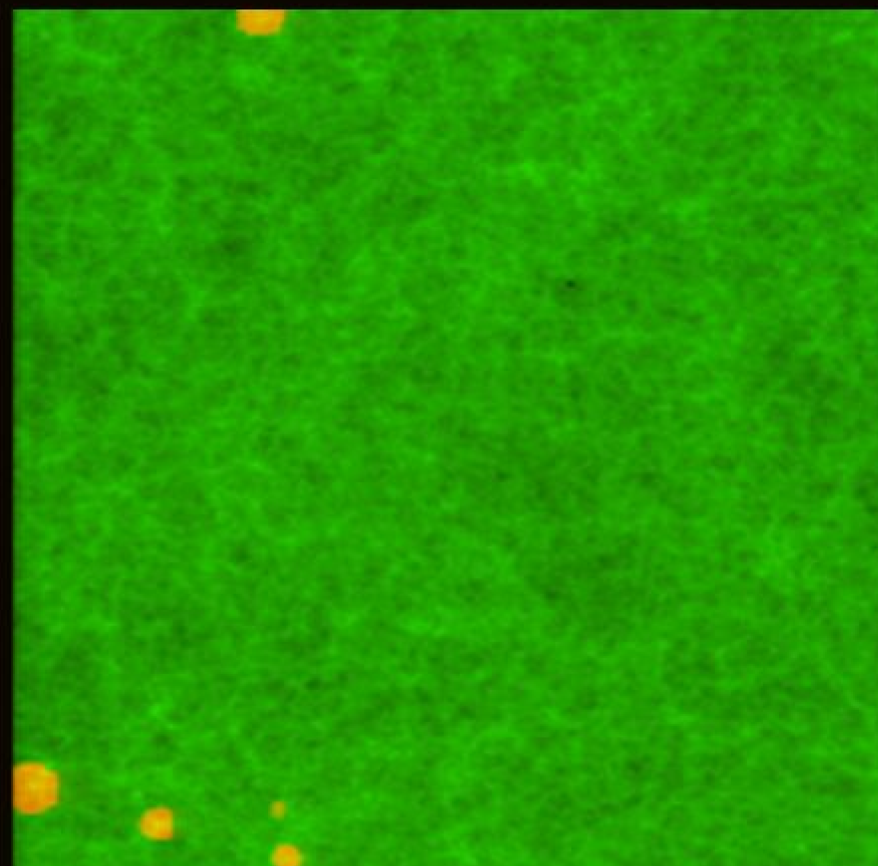

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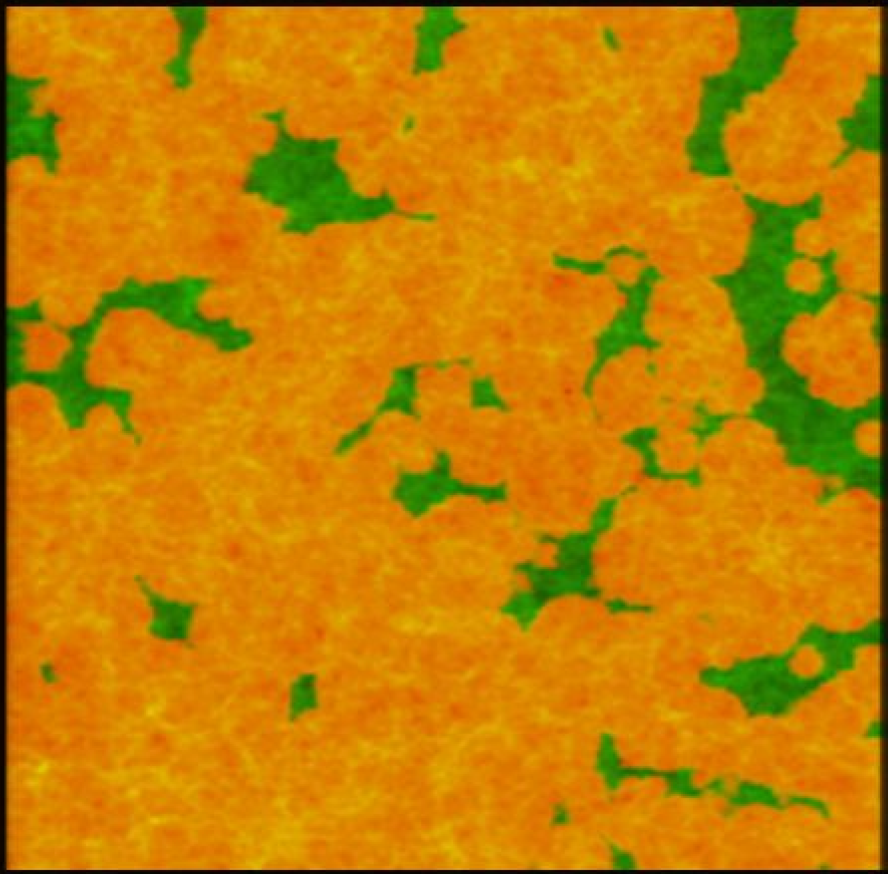

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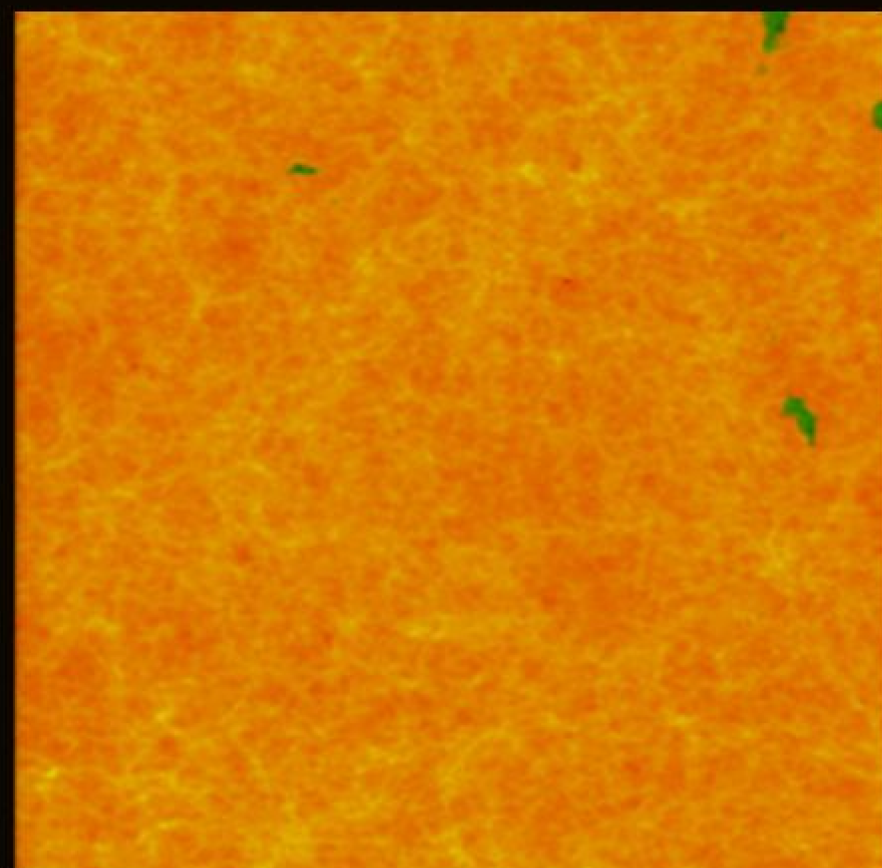

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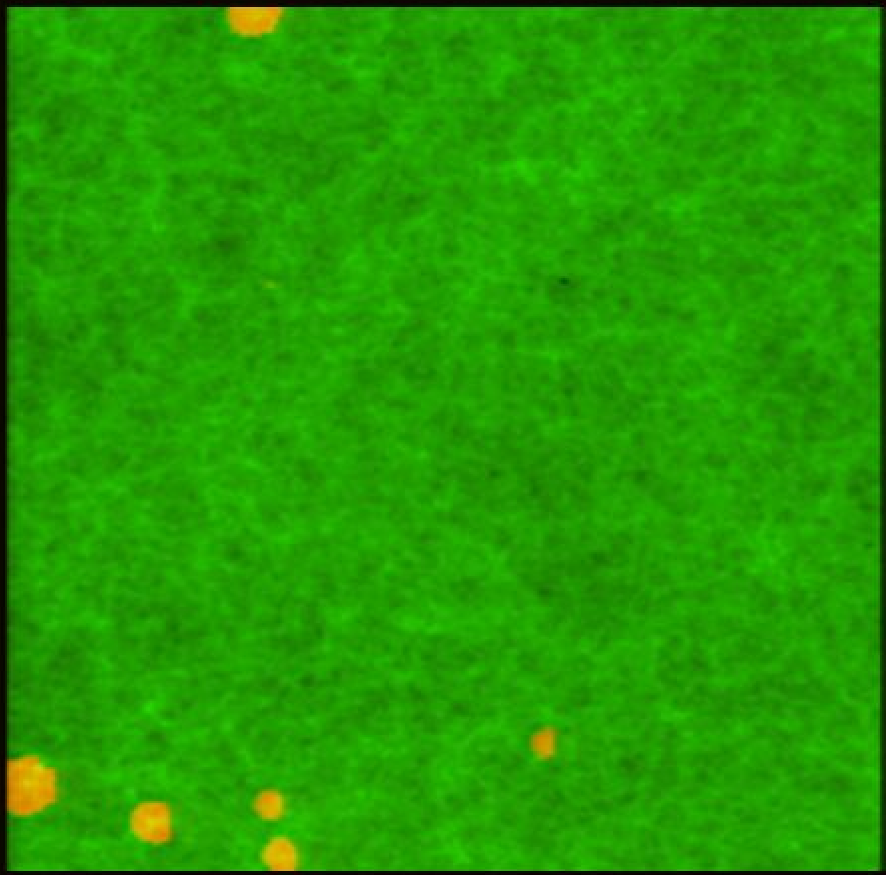

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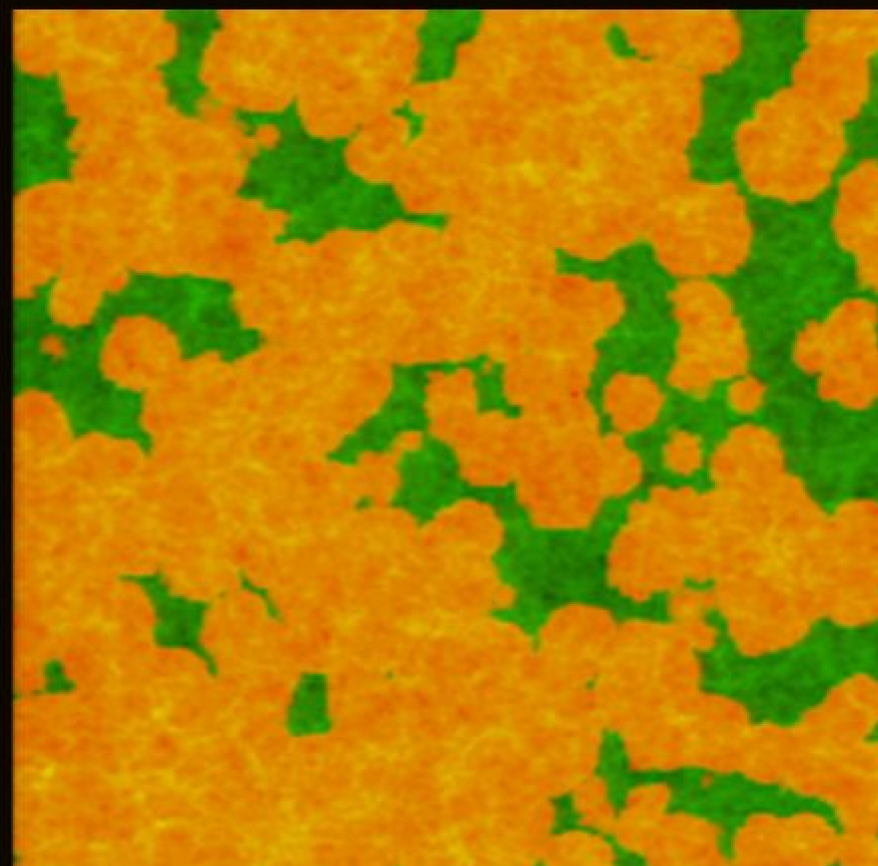

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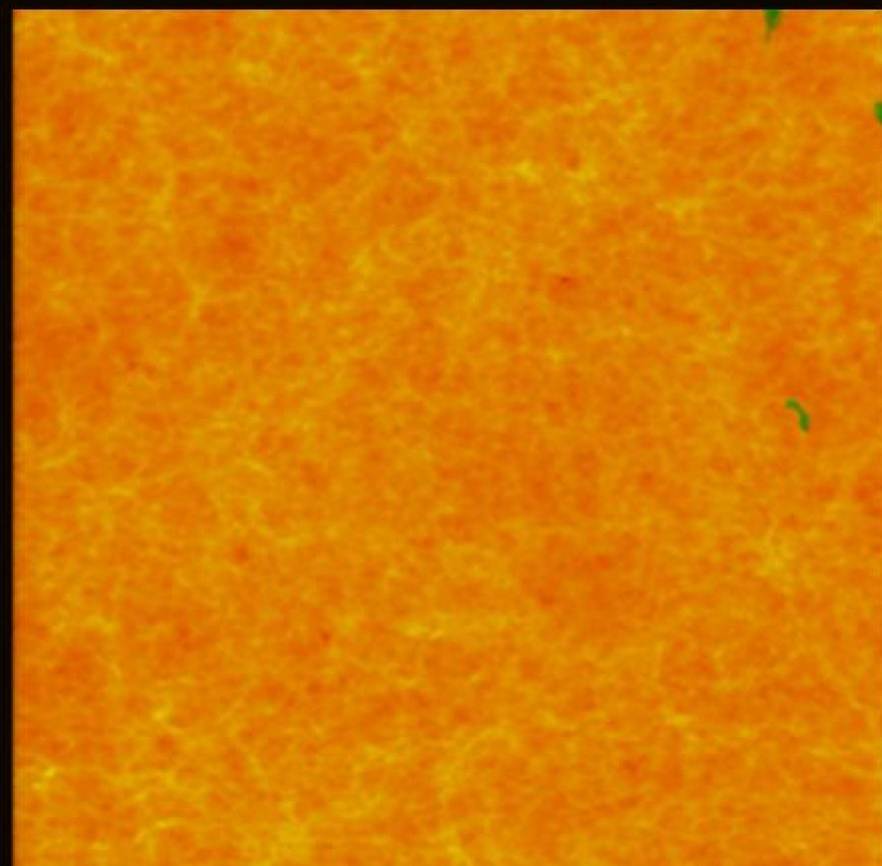

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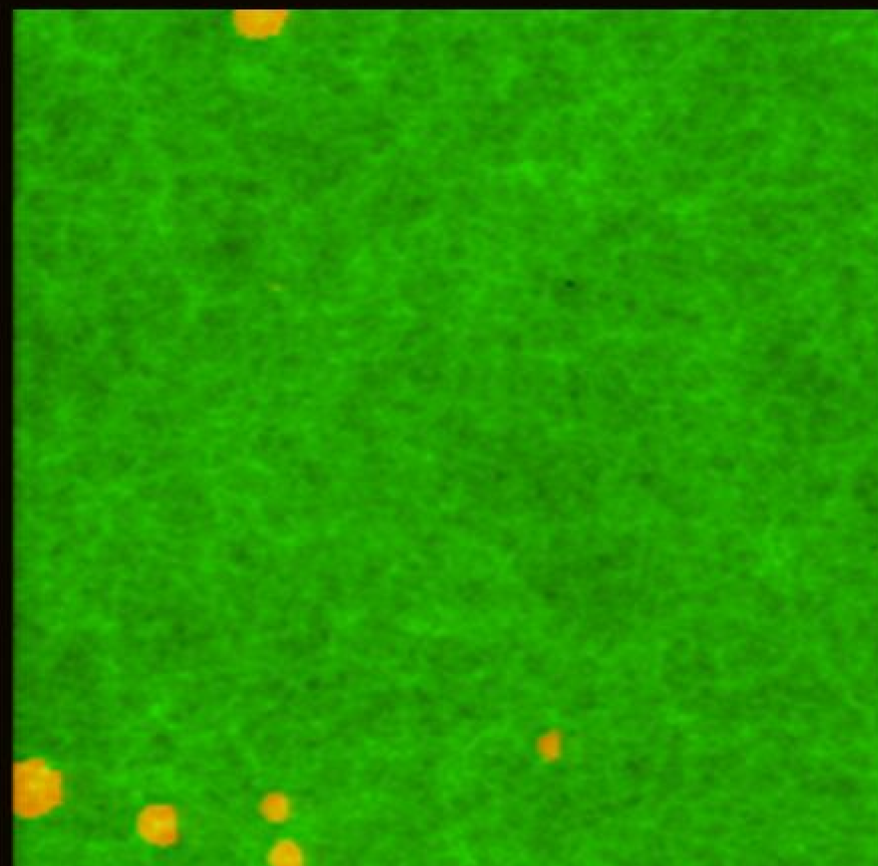

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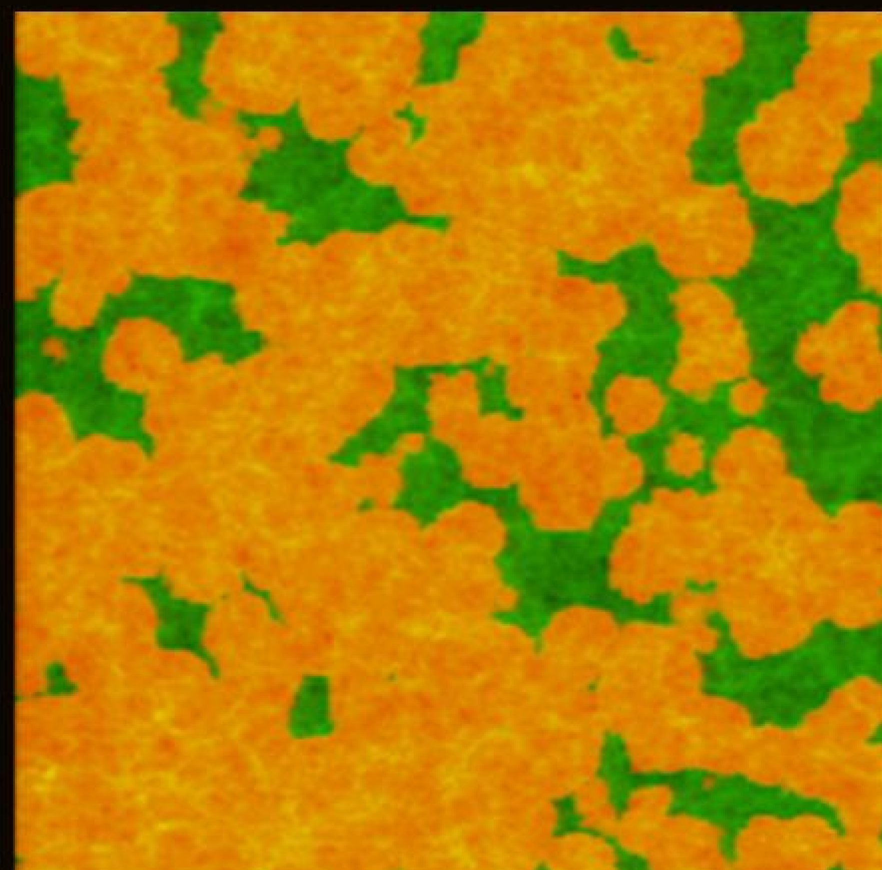

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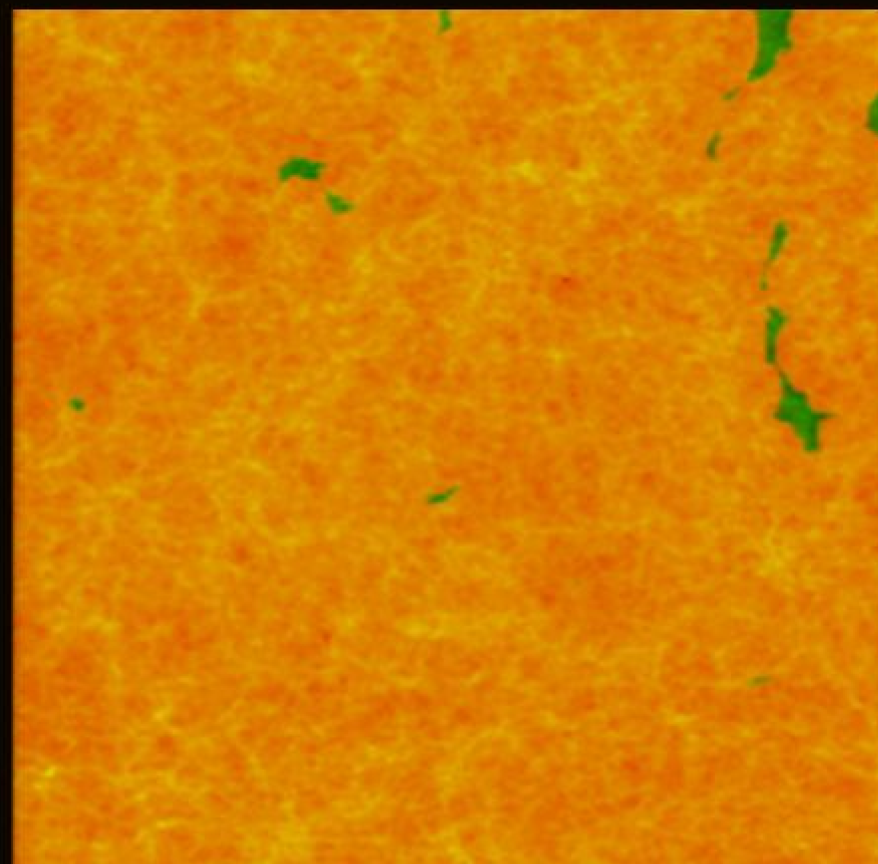

z=19-12 simulation, Iliev, Mellema, Pen 2005. 1° FOV

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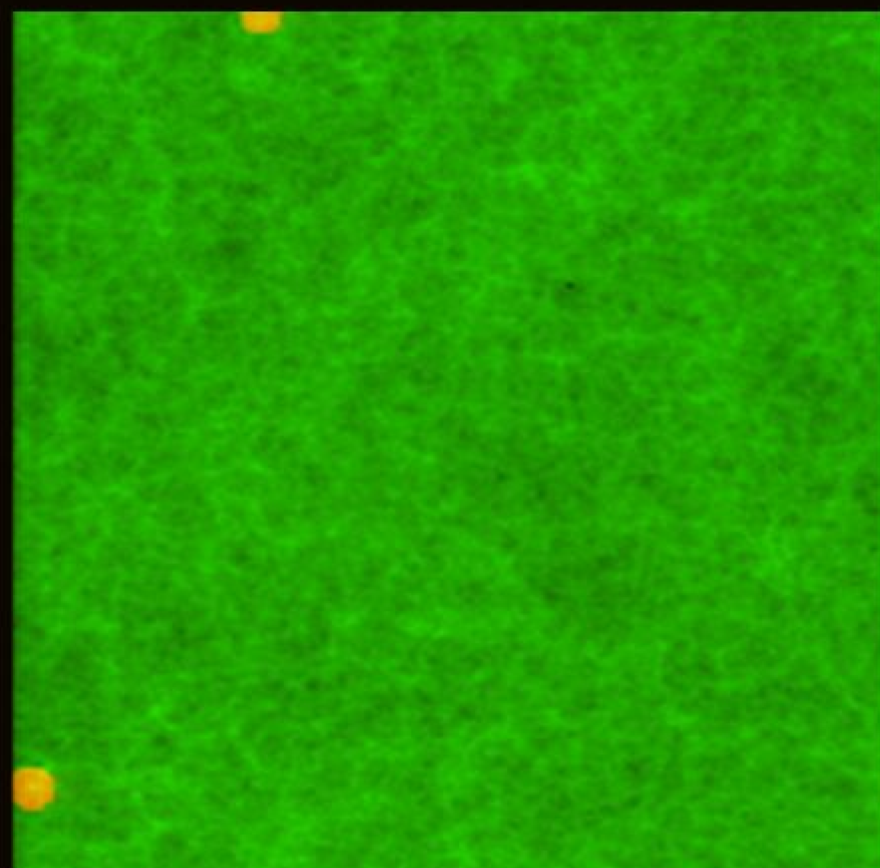

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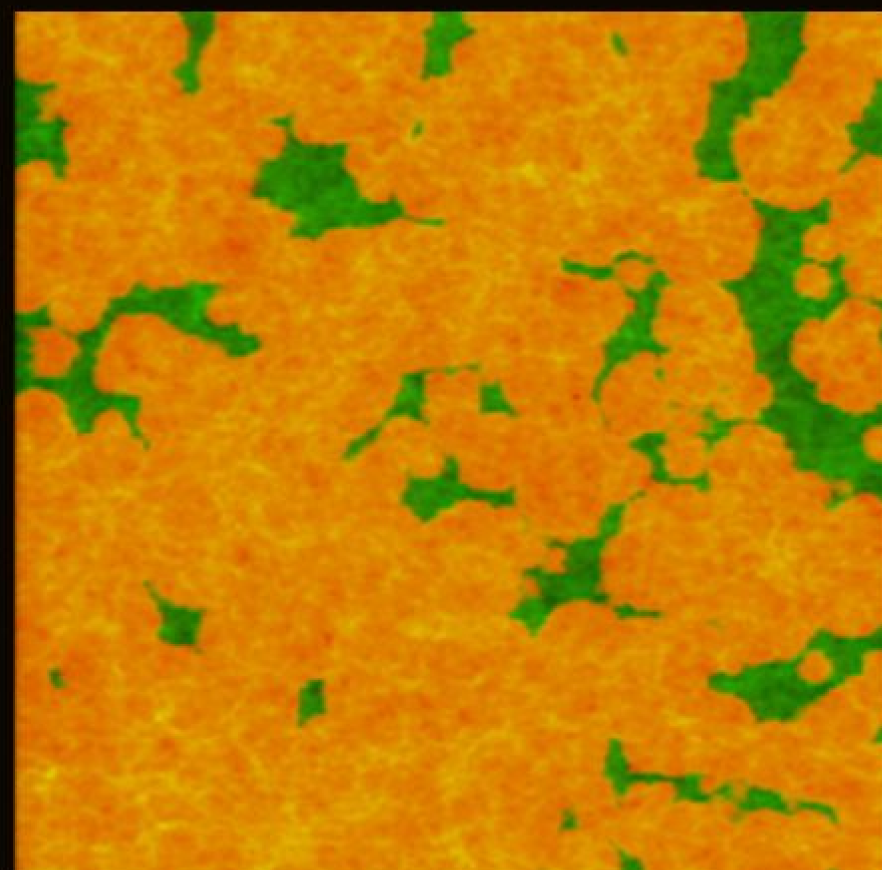

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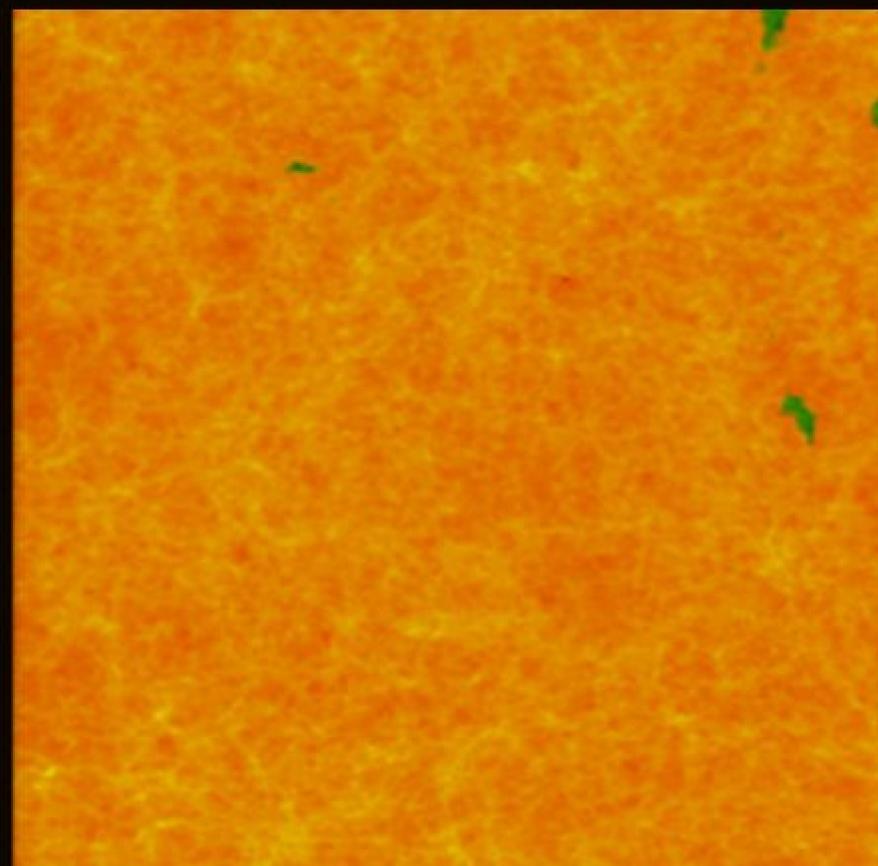

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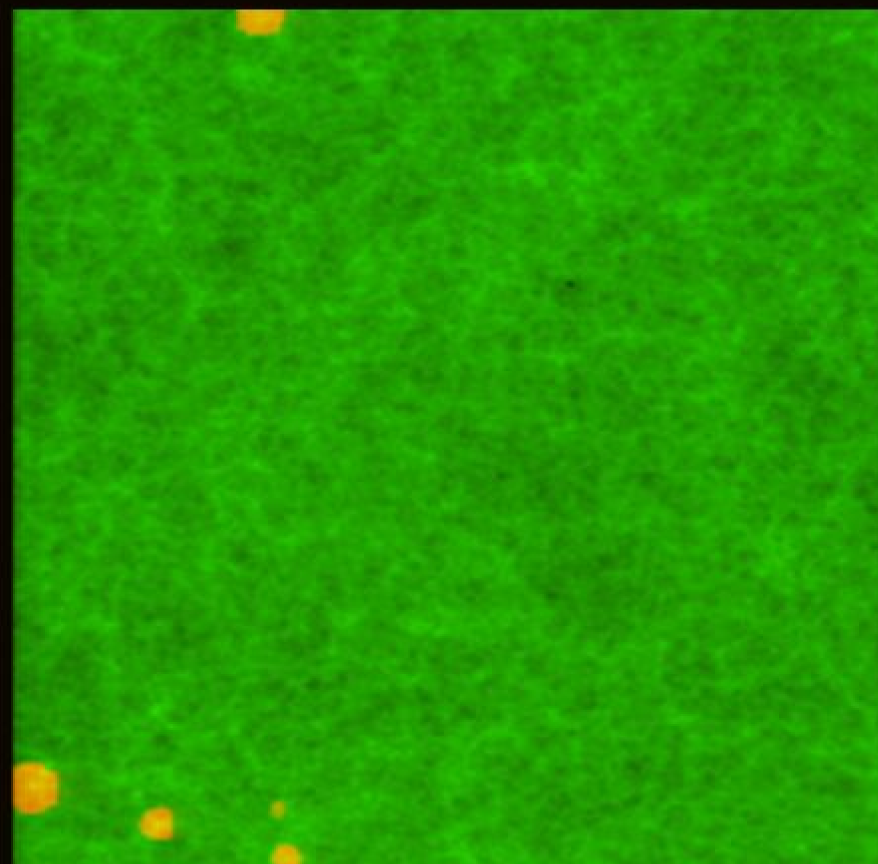

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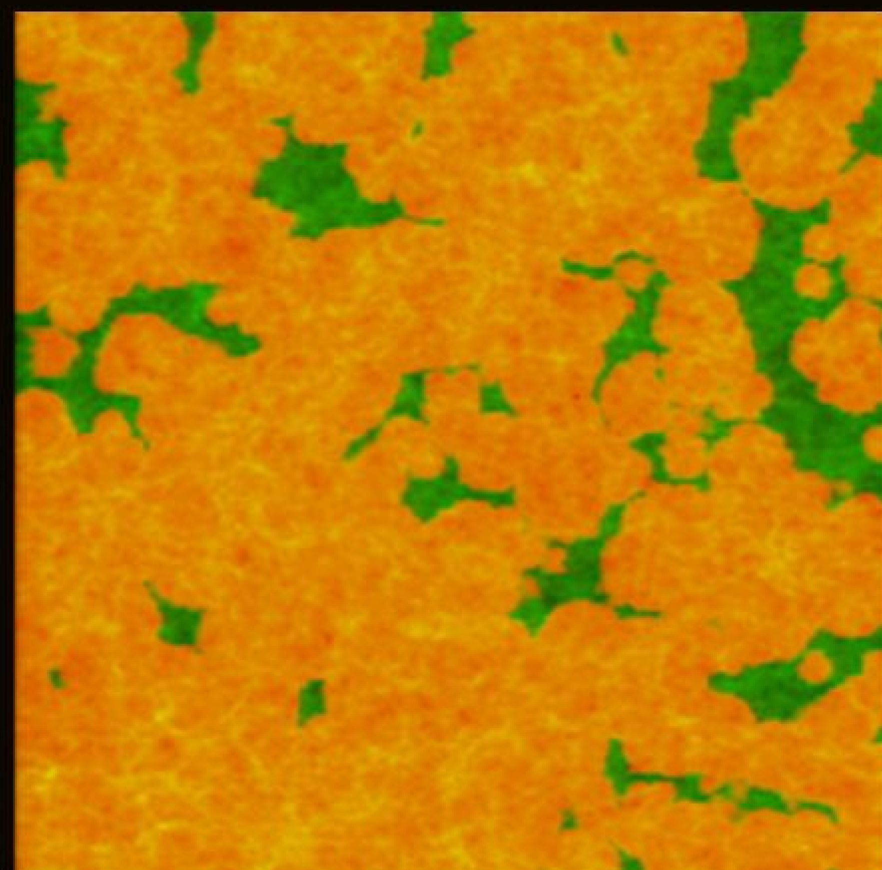

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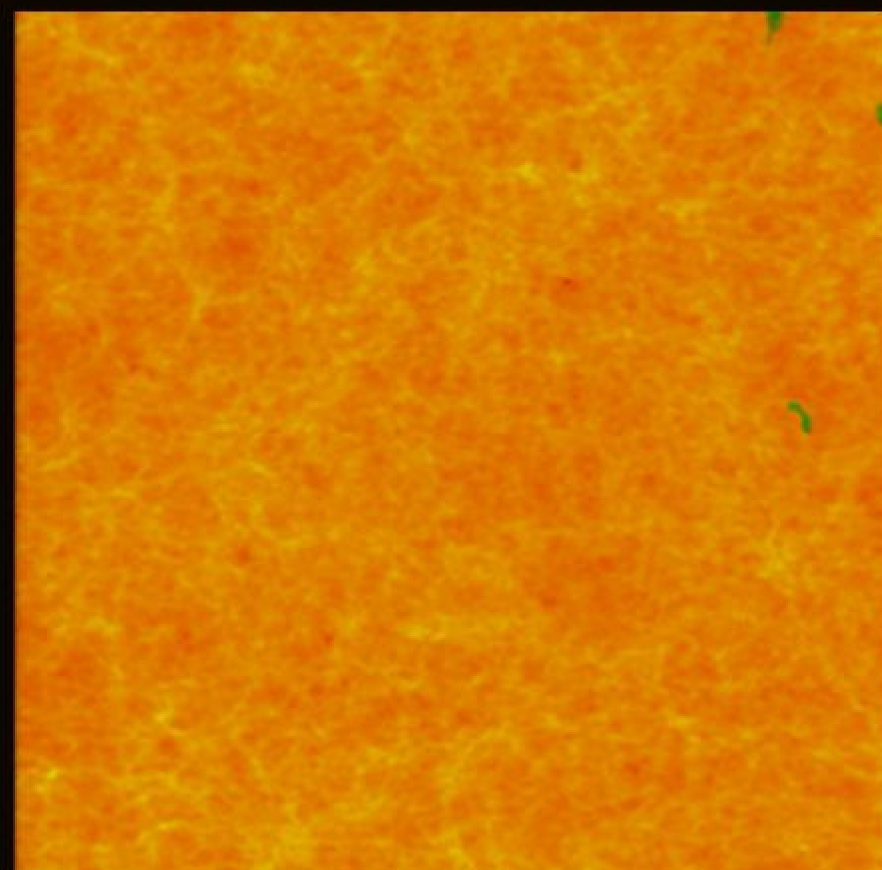

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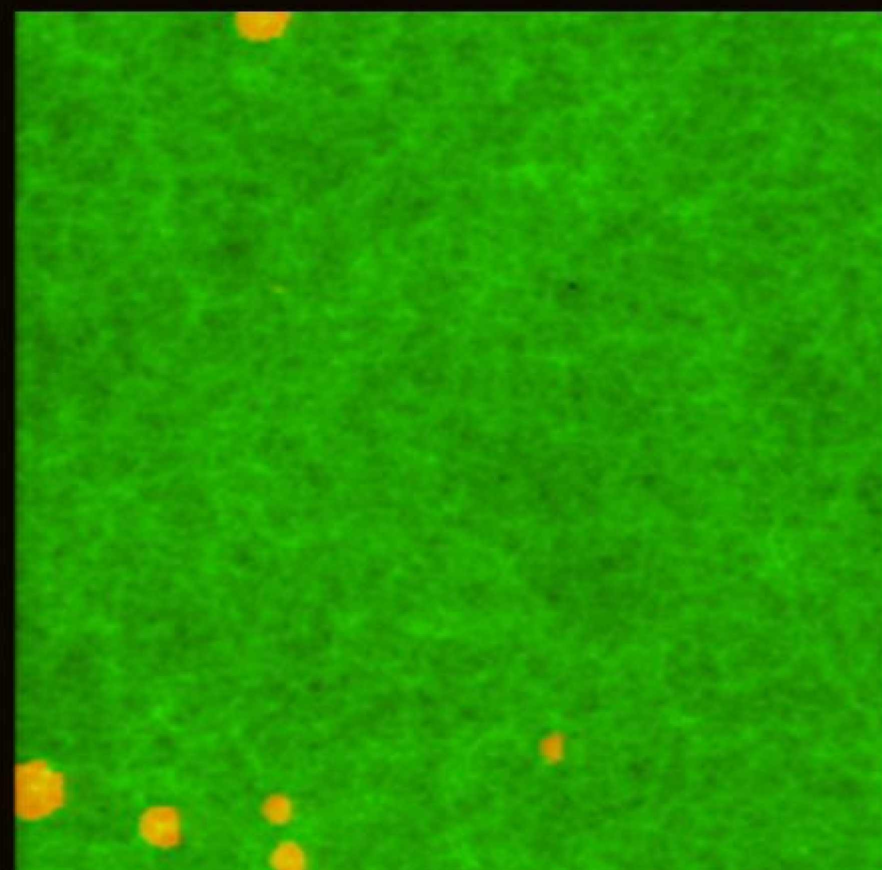

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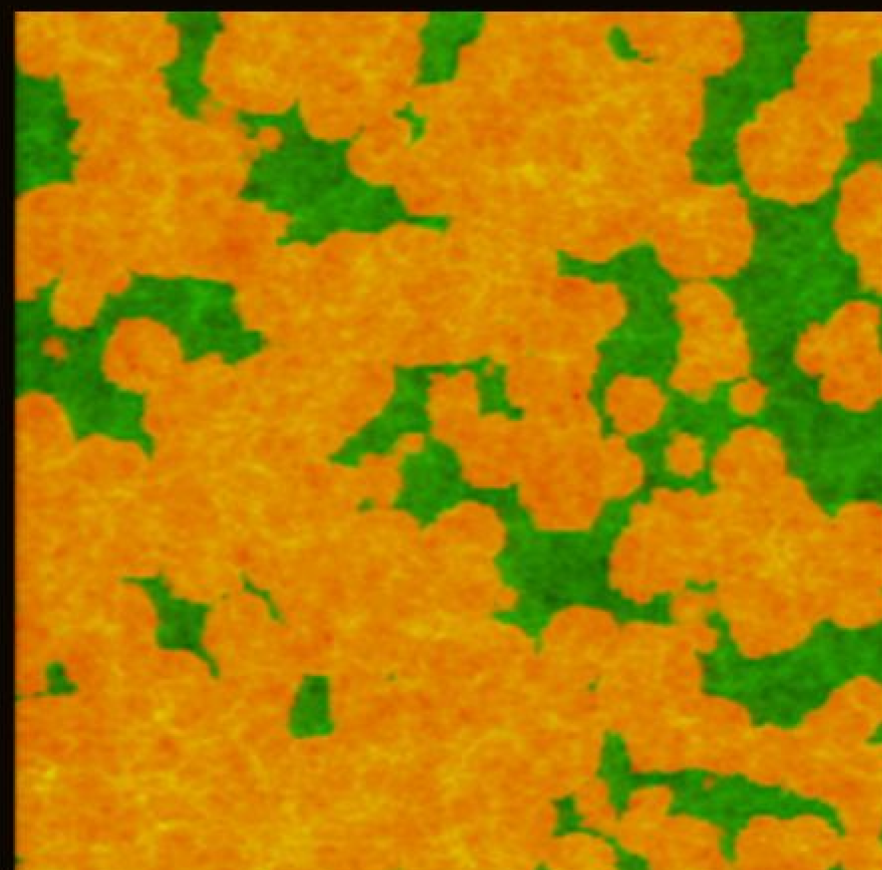

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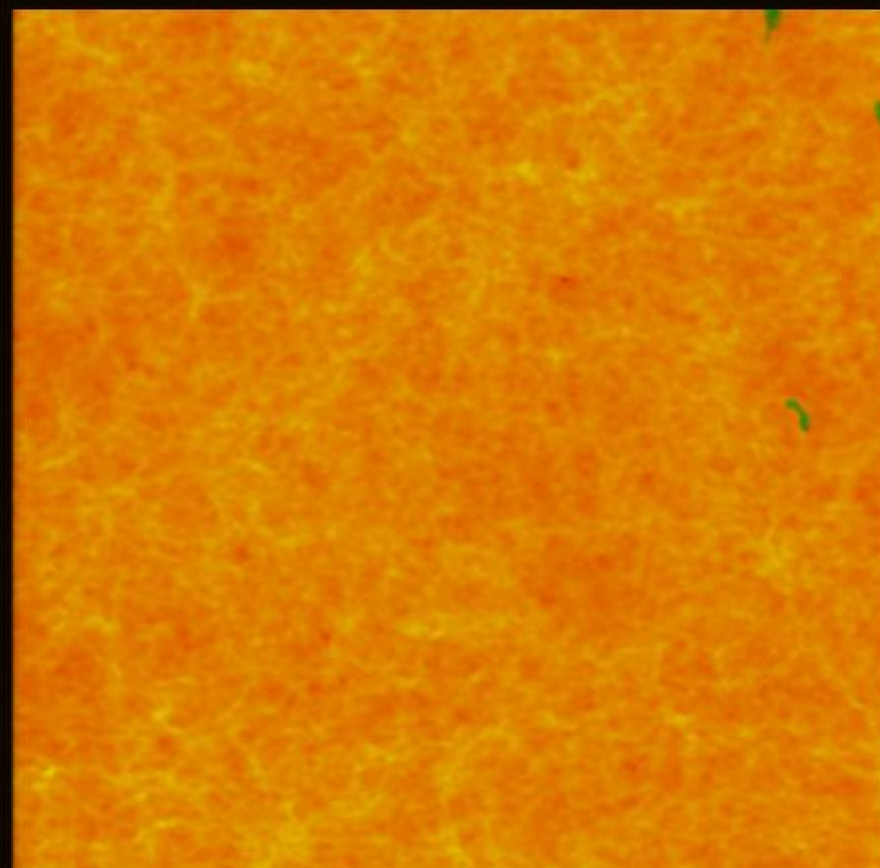

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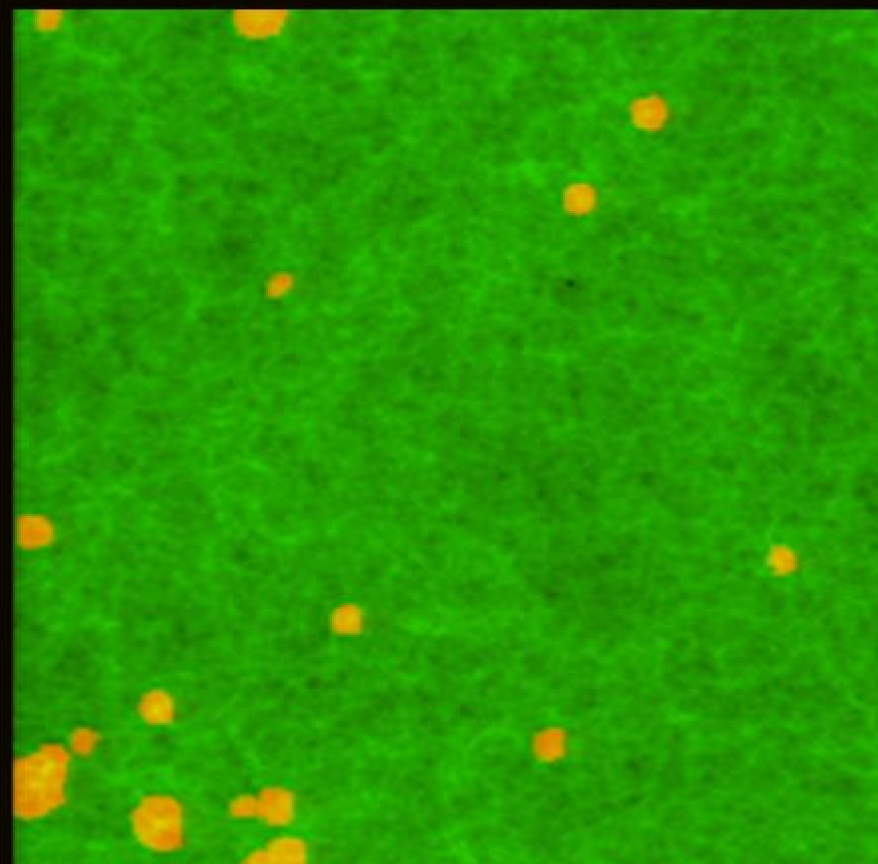

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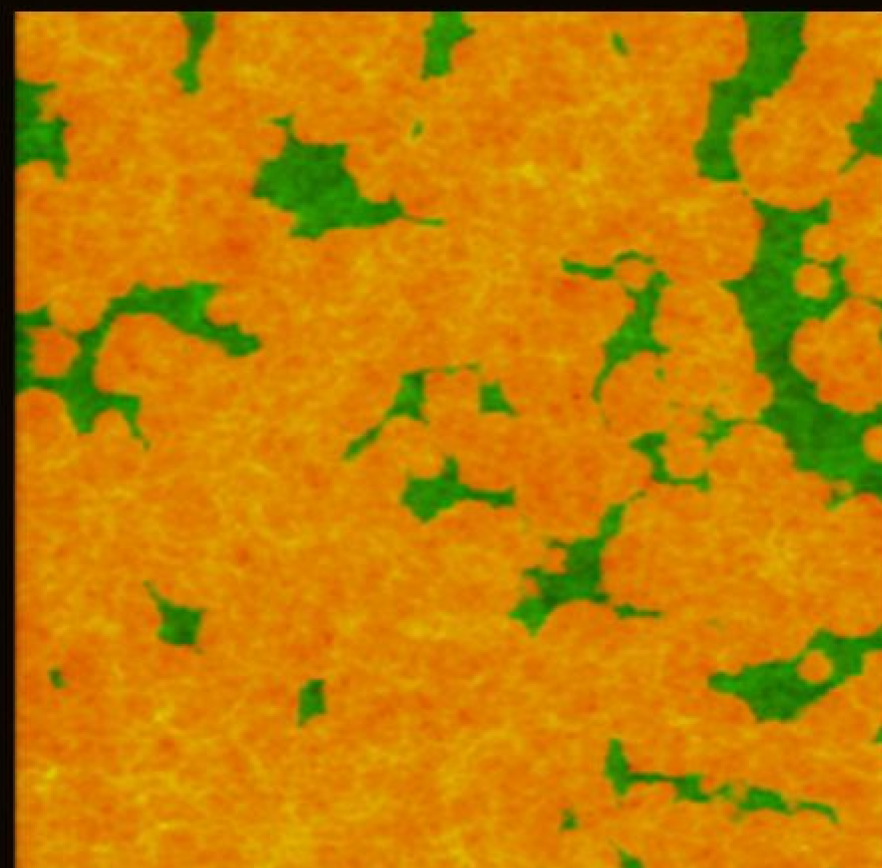

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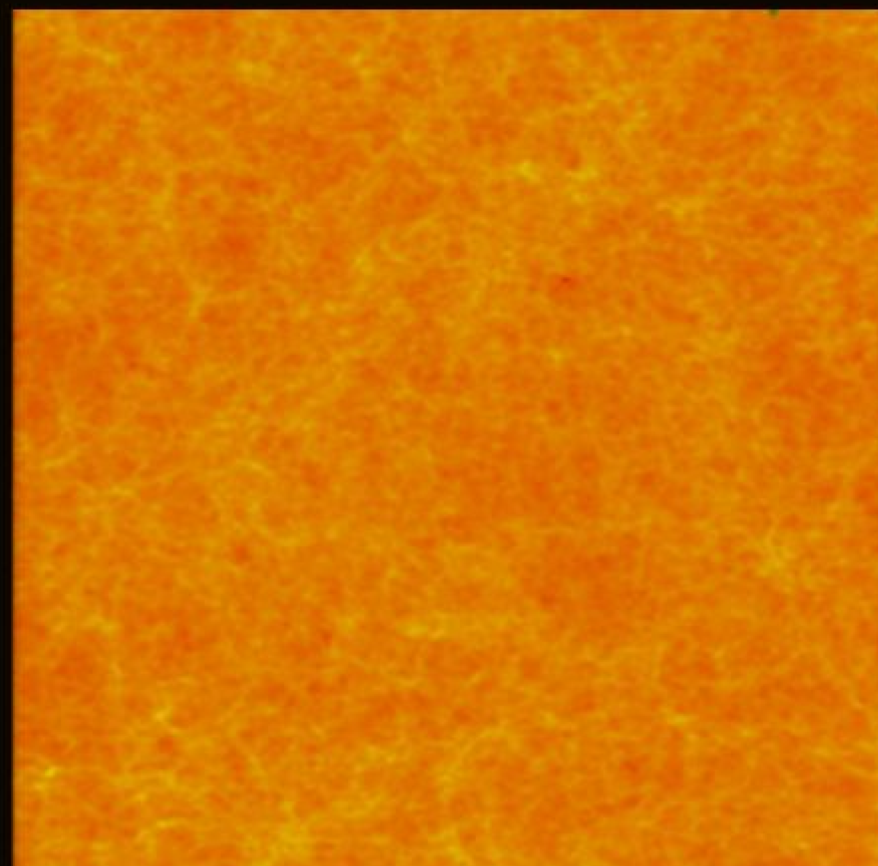

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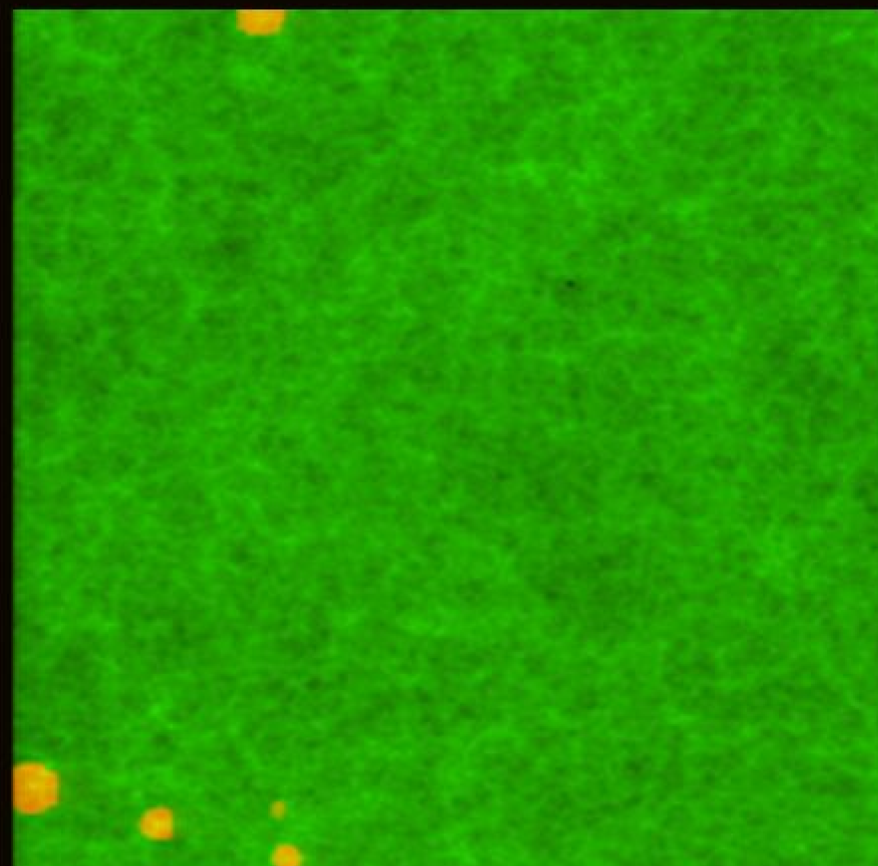

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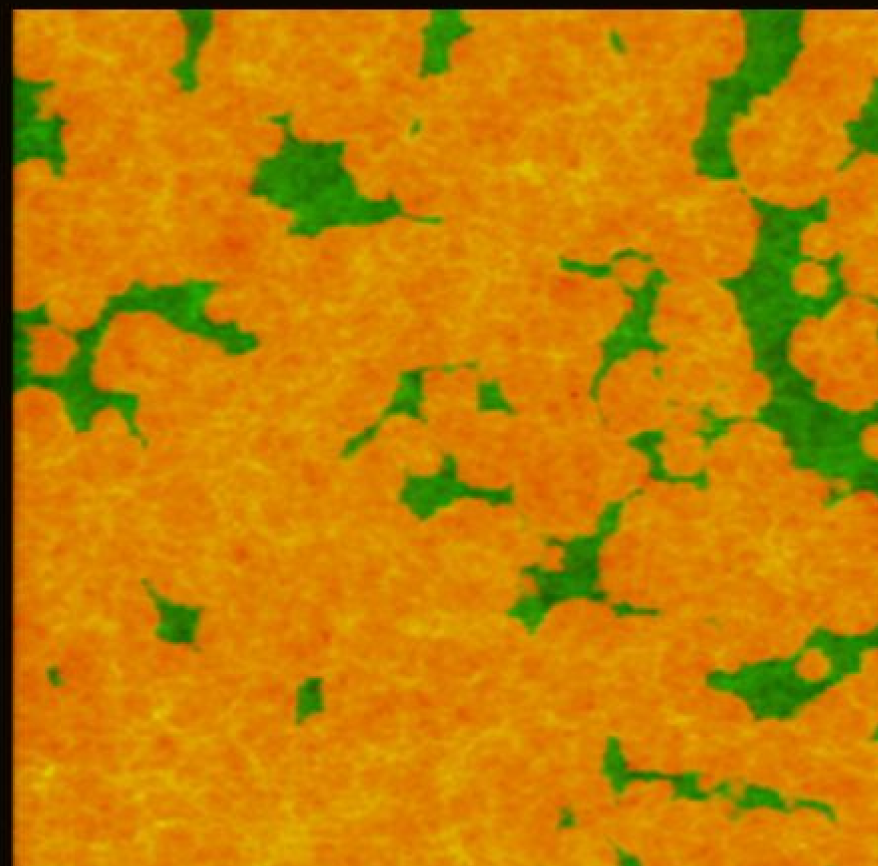

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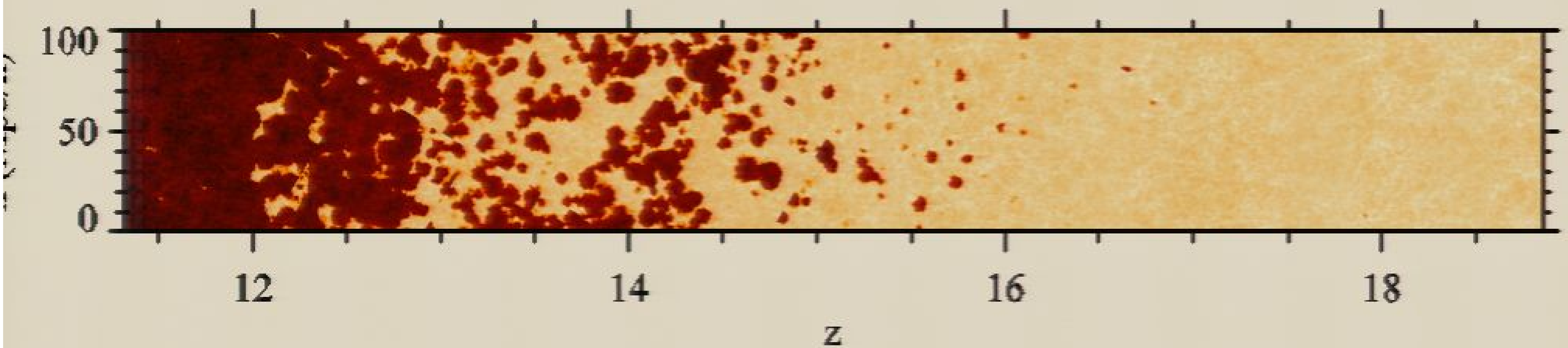
Cosmic Reioniation



Largest radiative transfer cosmological reionization simulations: 1 degree FOV.

Detection in 21cm hyperfine transition with radio telescopes. Structure on large scales (>20').

Iliev, Mellema, Pen 2006

First Light Experiments

- Existing: PAST/21CMA (China), GMRT (India)
- Under construction: LOFAR (Netherlands), T-rex (Canada), CoRE (Australia) VLA-VHF (USA)
- just funded: MWA (MIT/Australia)
- Future: SKA, JWST


Schleswig-
Holstein
Nordsee
Bremen
Nordrhein -
Westfalen
Hessen
Belgie

LOFAR

Mileura Wideangle Array

The VLA EOR Extension Program

(cfa-www.harvard.edu/dawn)

ponents: http://astrosun2.astro.cornell.edu/academics/courses//astro201 & courtesy of NRAO/AUI

- Led by the H.S.-CfA
  - *Collaboration with NRAO*
  - *Funded by SAO*
  - *Engineering by SAO Receiver Lab*
  - *PIs:* *L. Greenhill, R. Blundell*
  - *co-Is:* *C. Carilli, S. Furlanetto, A. Loeb, R. Perley, M. Zaldarriaga*
  - *Techs:* *R. Kimberk, S. Leiker, E. Tong, L. Peritz, I. Ginsburg*

Crash program to outfit the VLA for VHF operation in 2005/7

Goals

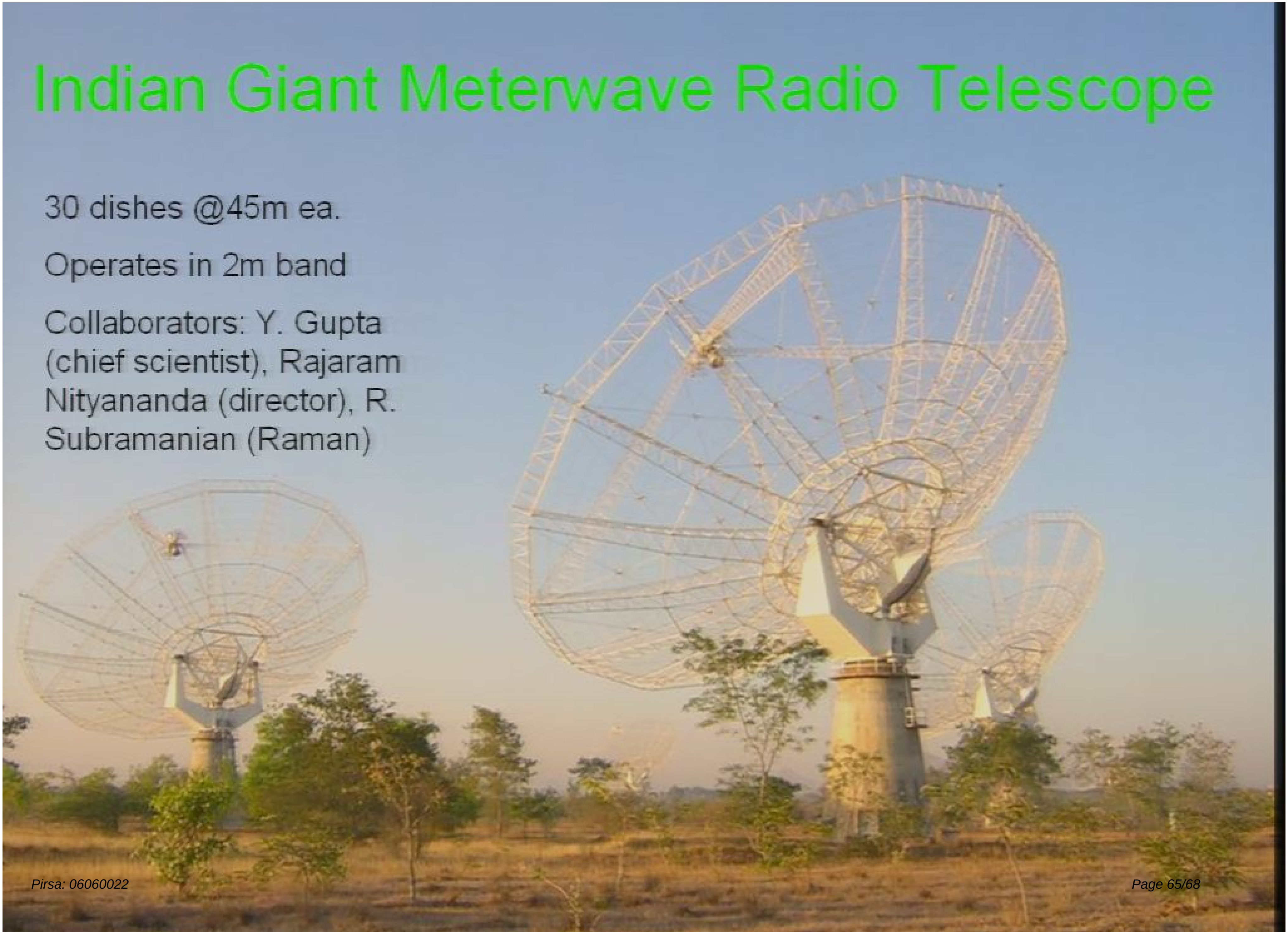
- *detection of quasar HII regions. In parallel, HI fluctuations (z=6.2-6.5)*
- *pathfinder / build experience for MWA-LFD & other facilities*

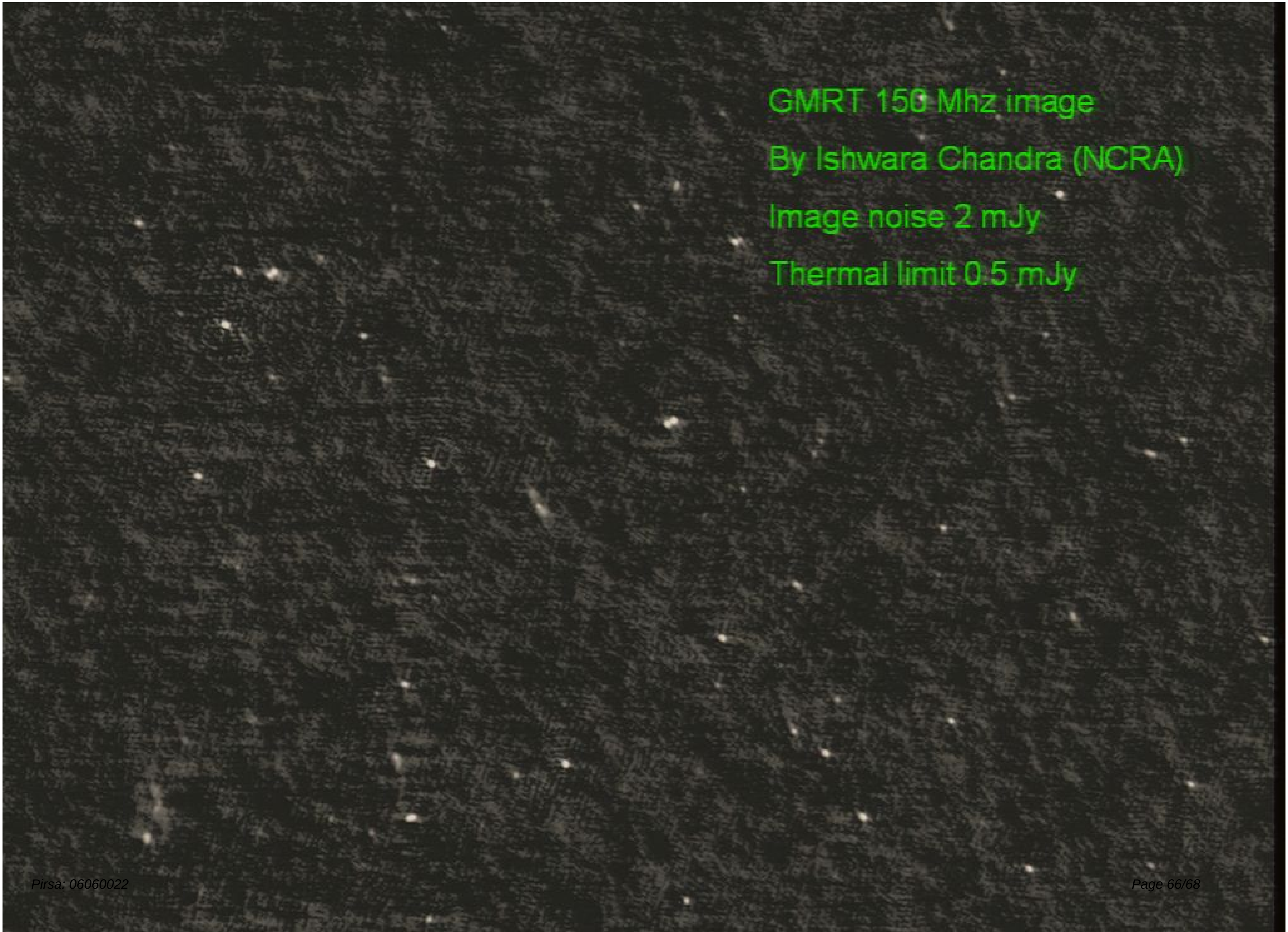
Indian Giant Meterwave Radio Telescope

30 dishes @45m ea.

Operates in 2m band

Collaborators: Y. Gupta (chief scientist), Rajaram Nityananda (director), R. Subramanian (Raman)




GMRT 150 Mhz image
By Ishwara Chandra (NCRA)
Image noise 2 mJy
Thermal limit 0.5 mJy

Potential Theoretical Benefits

- Precision measurement of power spectrum at up to 10^{-8} accuracy
- Dark energy dynamics: q_0, a(t), ISW, dark matter dynamics/clustering (through lensing), gravity waves.
- Initial conditions: 2nd order inflation effects, backreaction, curvature, etc. (through hydrogen matter P(k) and 3pcf).

Outlook

- Most abundant element in universe is H, surveys feasible to z>10 at modest costs
- Bright outlook: several EoR and 21cm experiments underway or planned to tap the next cosmic horizon
- Exciting new window on universe for precision cosmology: in principle, almost unbounded information