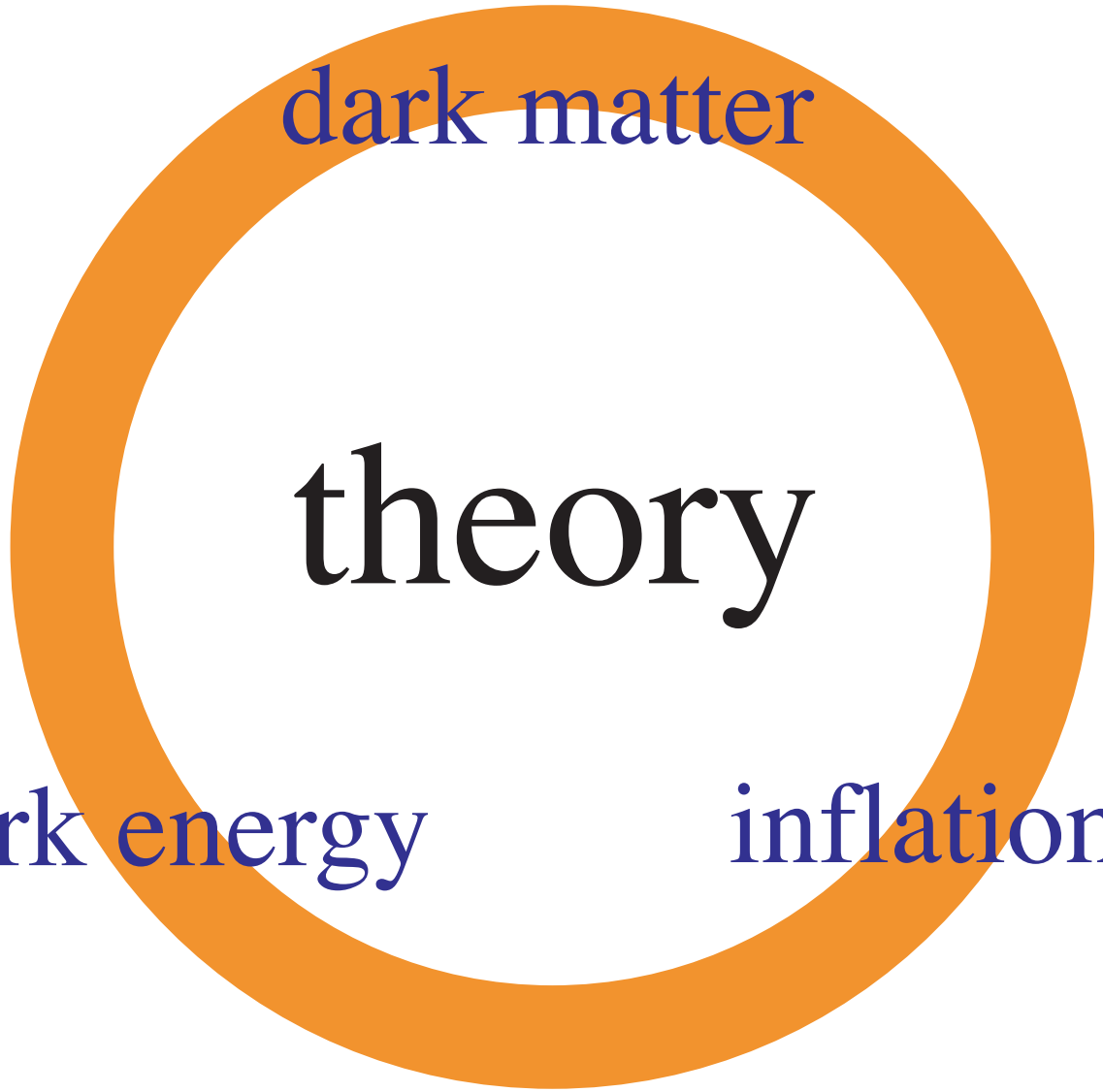


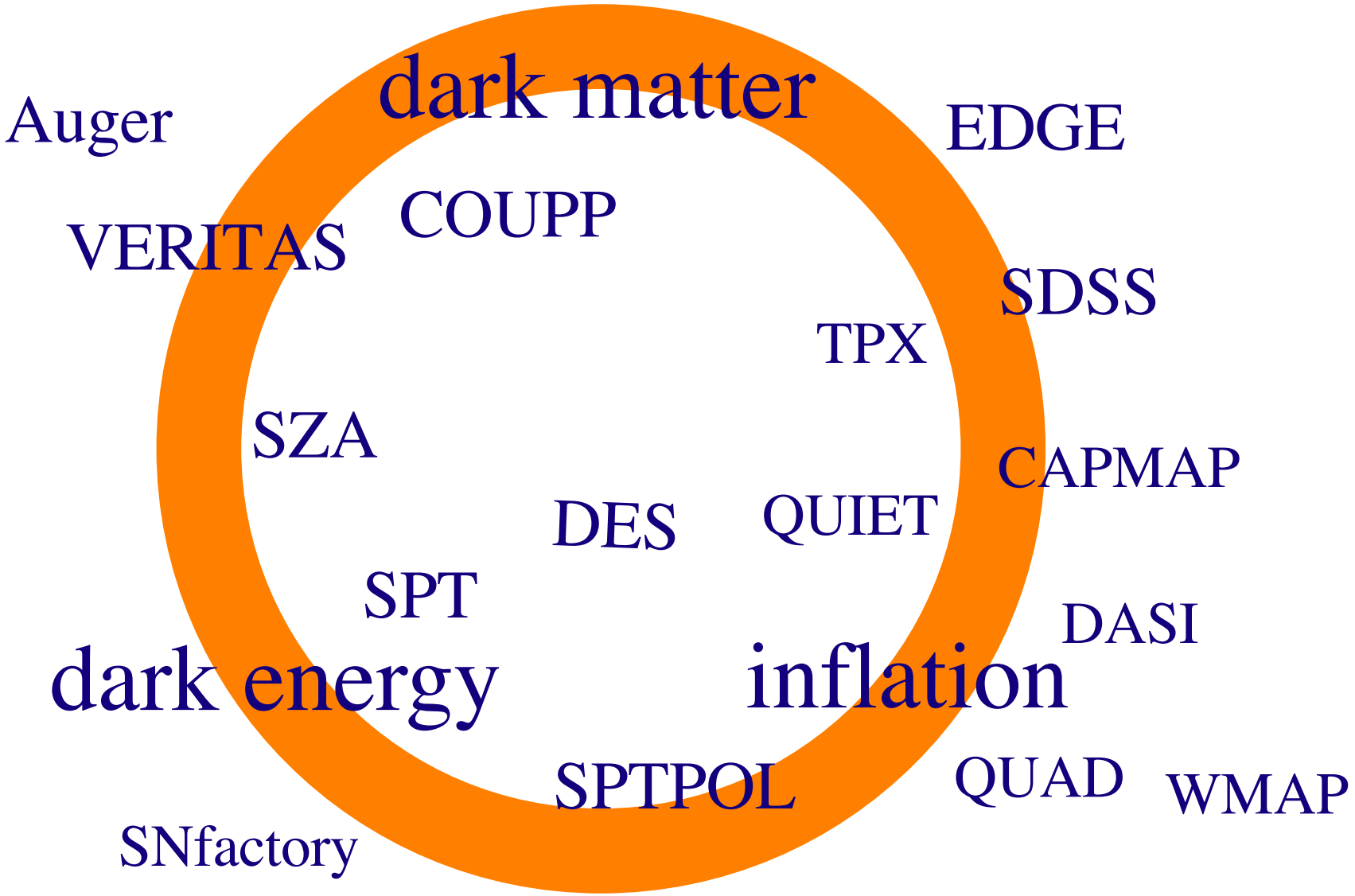
NSF Site Review
November 28-29, 2005

The National Science Foundation

The Kavli Foundation

The Theoretical Web

Entangles KICP Experiments



Roles Played by KICP Theorists

- Elucidation of predictions for cosmological observables
- Development and implementation of techniques to connect observations to theories
- Investigation of the discovery potential of experimental projects
- Development of new theories as the data require it

Roles Played by KICP Theorists

- Elucidation of predictions for cosmological observables
- Development and implementation of techniques to connect observations to theories
- Investigation of the discovery potential of experimental projects
- Development of new theories as the data require it

(require for a theorist = 2σ!)

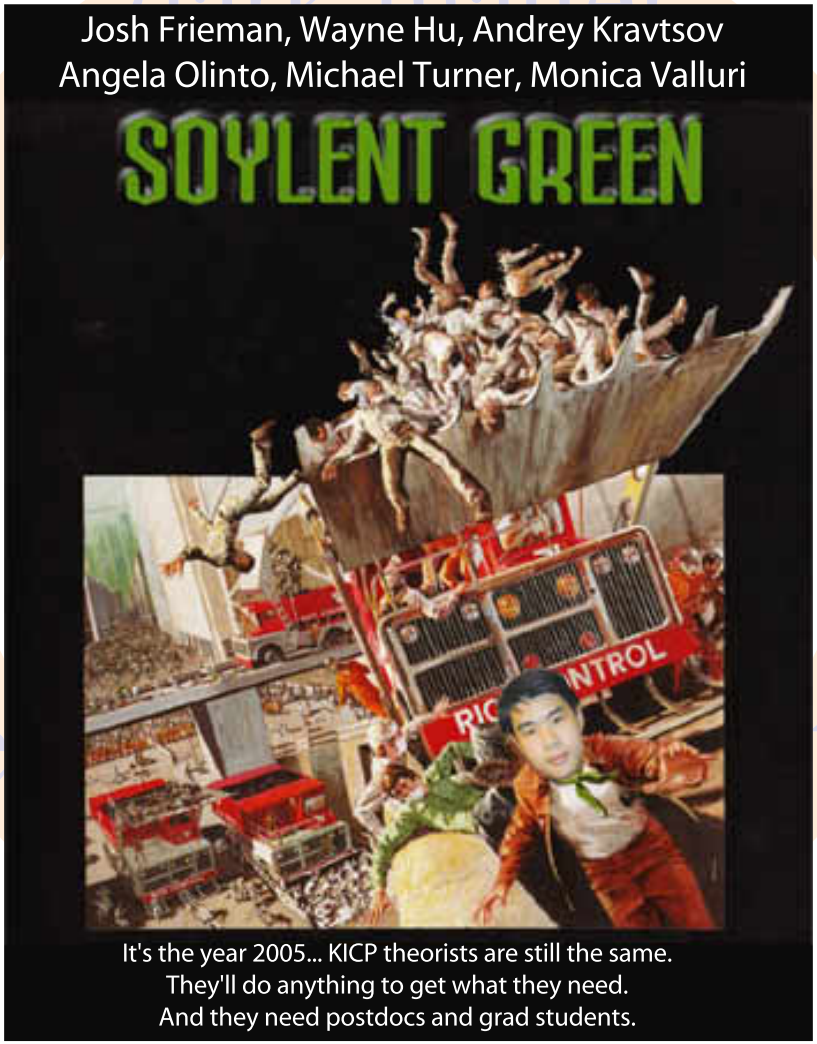
Theory = People

- Alumni

  Andreas Berlind
  Daniel Holz
  Erin Sheldon

- Present

  Simon DeDeo
  Christopher Gordon
  Vasiliki Pavlidou
  Xiaomin Wang
  Andrew Zentner



- Leveraged

  Dragan Huterer§
  Hiranya Peiris*¶
  Yong-Seon Song
  Jeremy Tinker
  Risa Wechler*¶

  §NSF Fellow
  *Hubble Fellow
  ¶Fermi Fellow

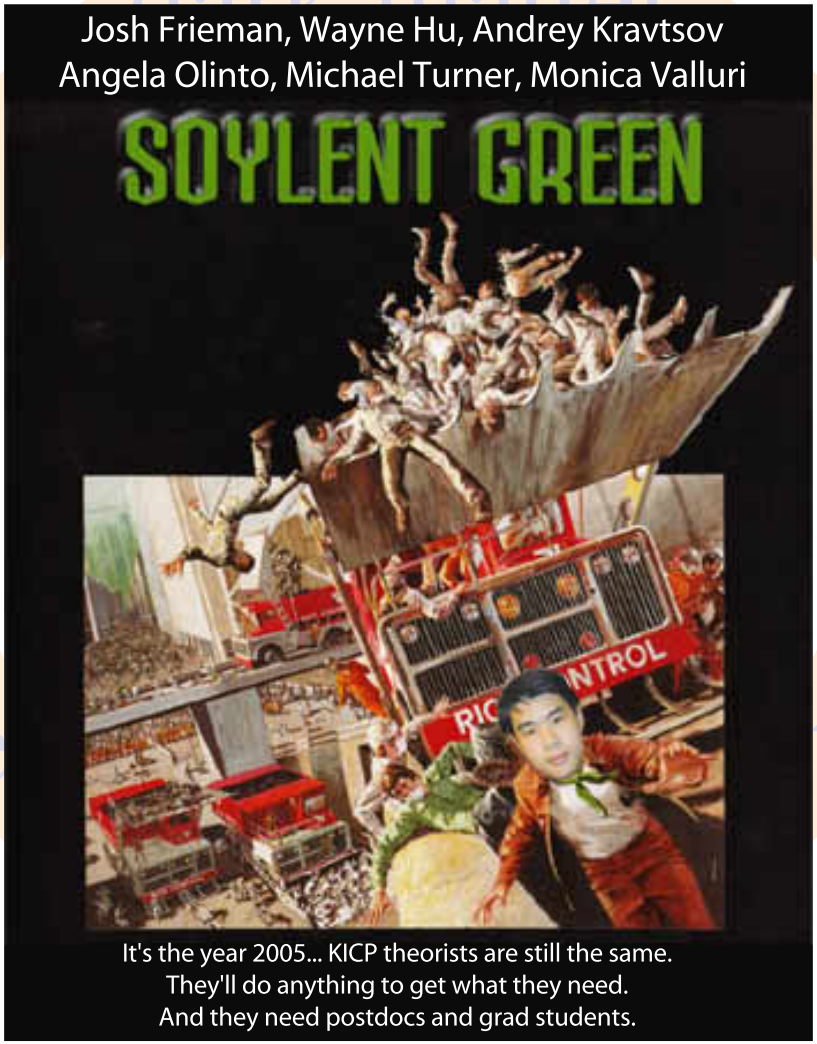
Theory = People

- Alumni

  Andreas Berlind
  Daniel Holz
  Erin Sheldon

- Present

  Simon DeDeo
  Christopher Gordon
  Vasiliki Pavlidou
  Xiaomin Wang
  Andrew Zentner



- Leveraged

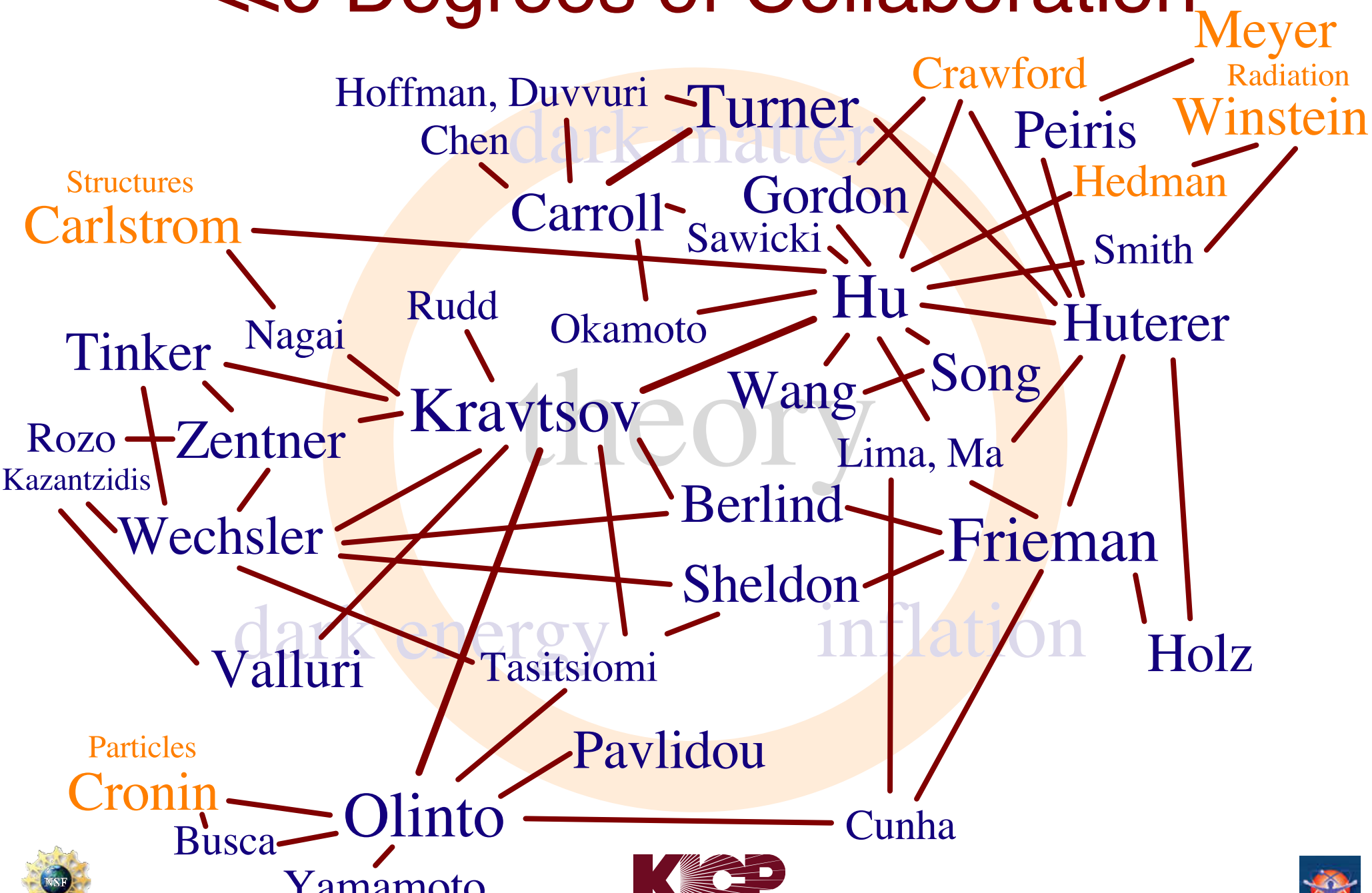
  Dragan Huterer§
  Hiranya Peiris*¶
  Yong-Seon Song
  Jeremy Tinker
  Risa Wechler*¶

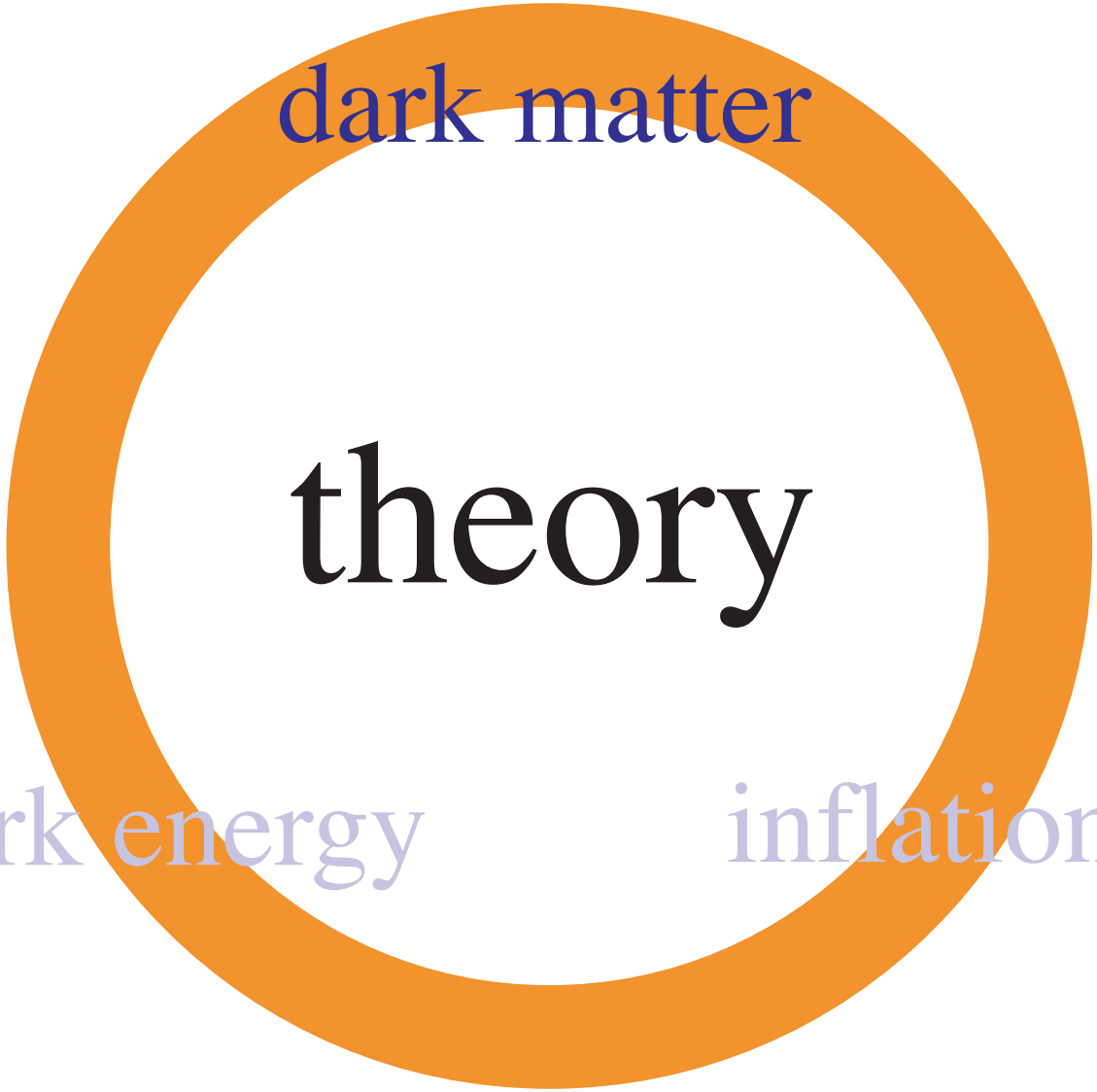
  §NSF Fellow
  *Hubble Fellow
  ¶Fermi Fellow

- AI Marvin

Andrey's Talk

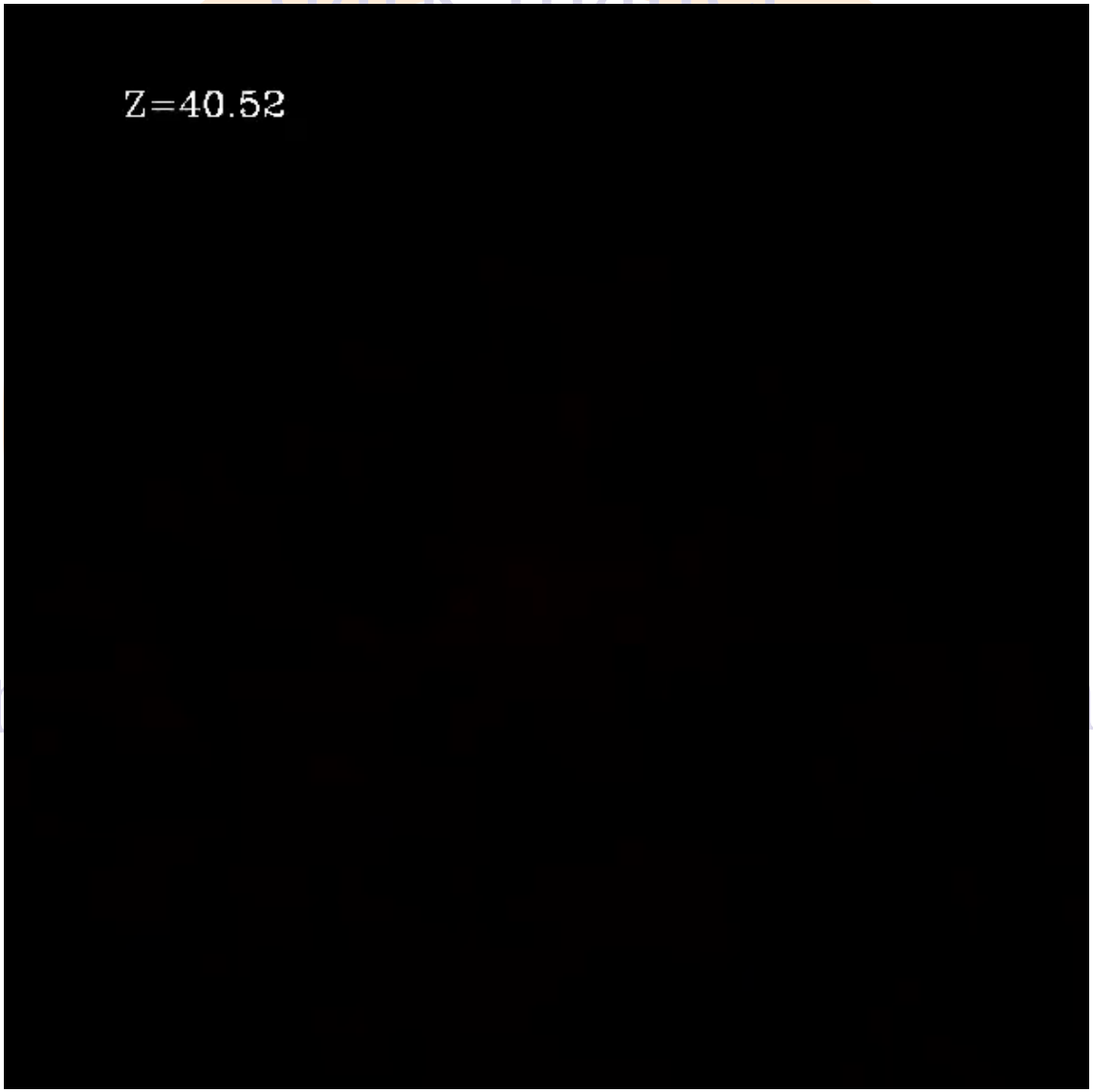
≪6 Degrees of Collaboration




dark matter
theory
dark energy
inflation

Dark Matter: Substructure

- Ultra-high resolution sims of halo substructure

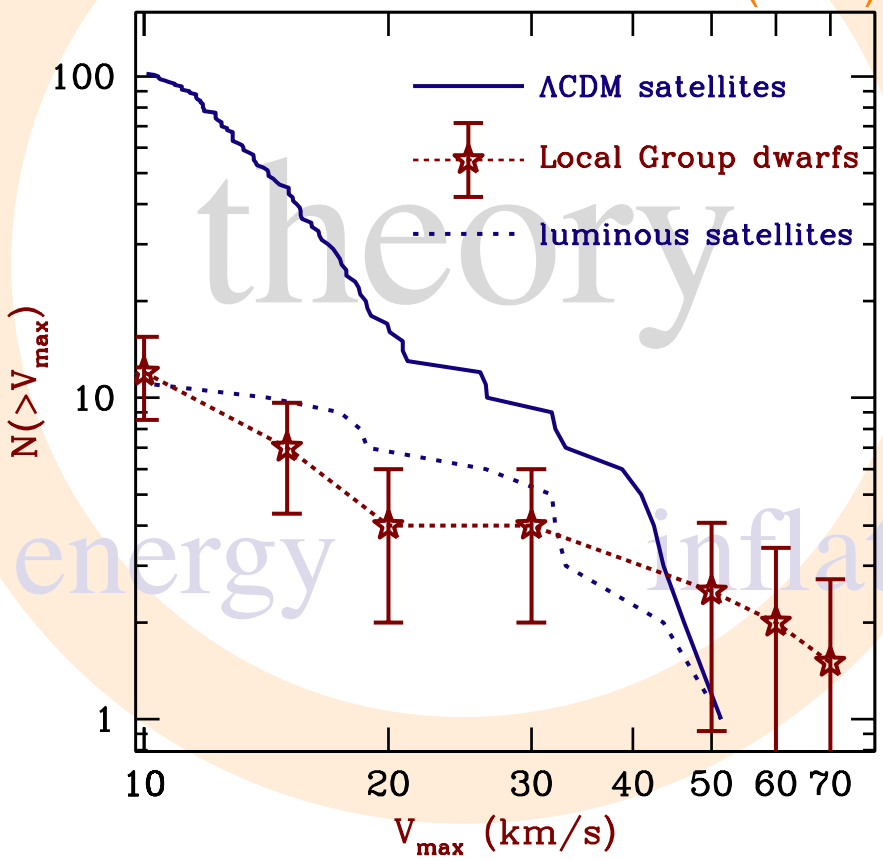


Kravtsov

Dark Matter: Substructure

- Reconciling halo substructure with dwarf satellite abundance: tidal stripping of luminous satellites

Kravtsov et al (2004)

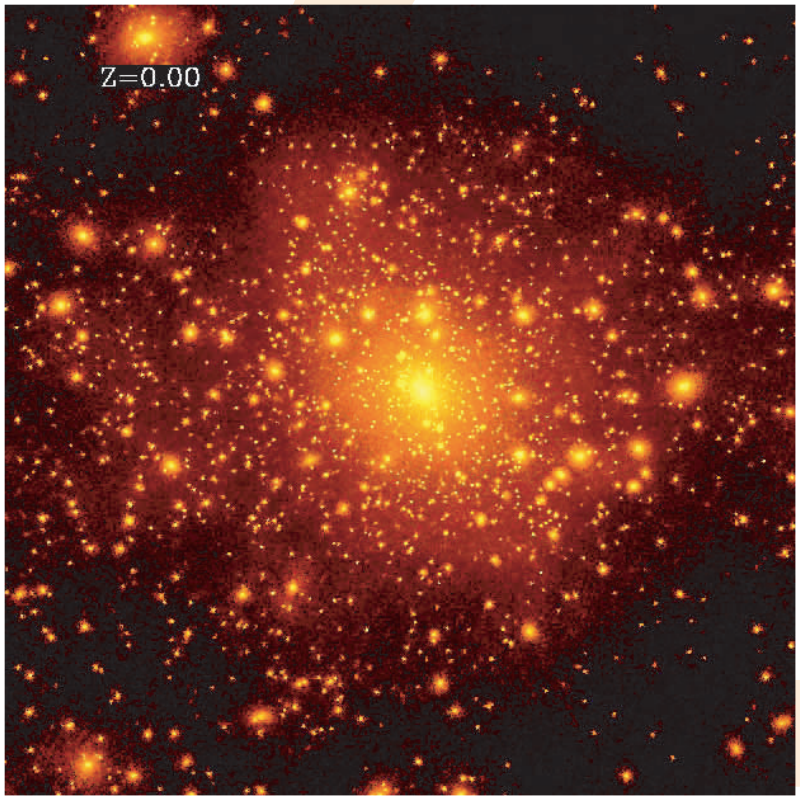


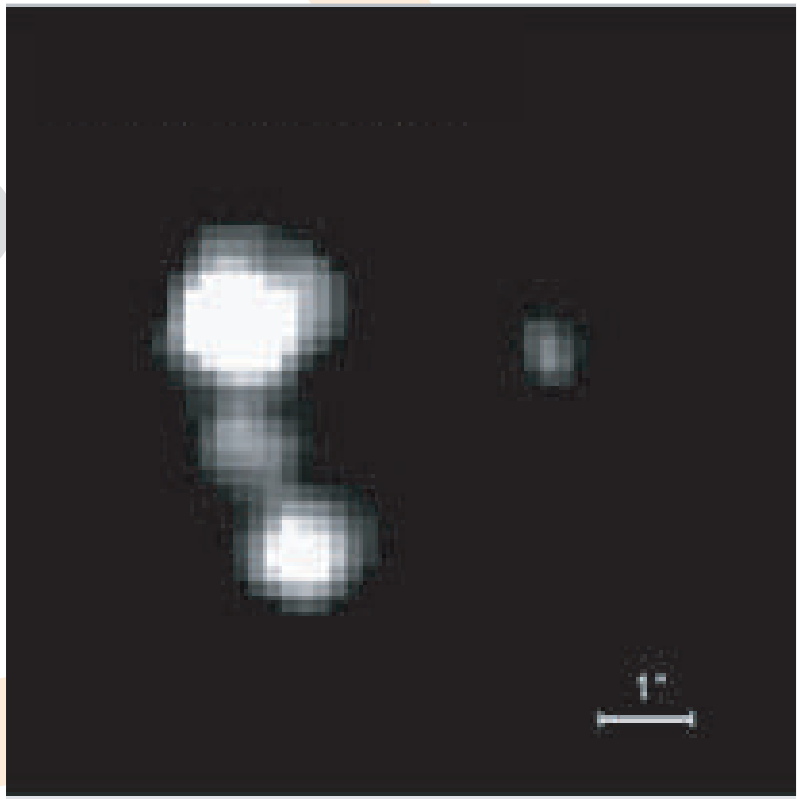
dark matter
theory
dark energy
inflation

Dark Matter: Substructure

- Detection in anomalous flux ratios of multiply imaged quasars? – projection & modelling

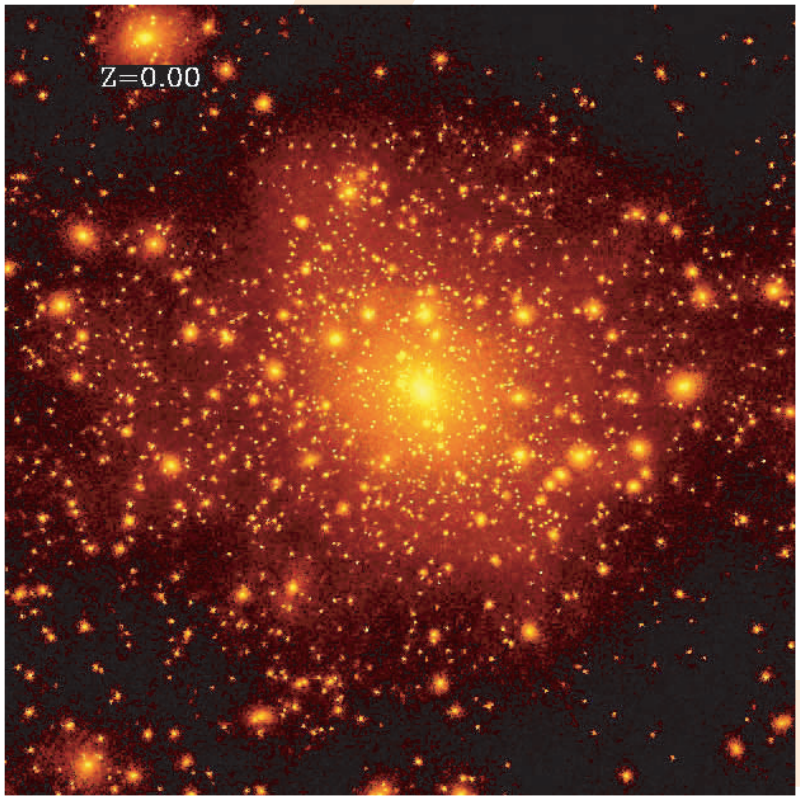
  Chen, Kravtsov, Keeton (2003); Rozo, Zentner, Bertone, Chen (2005)

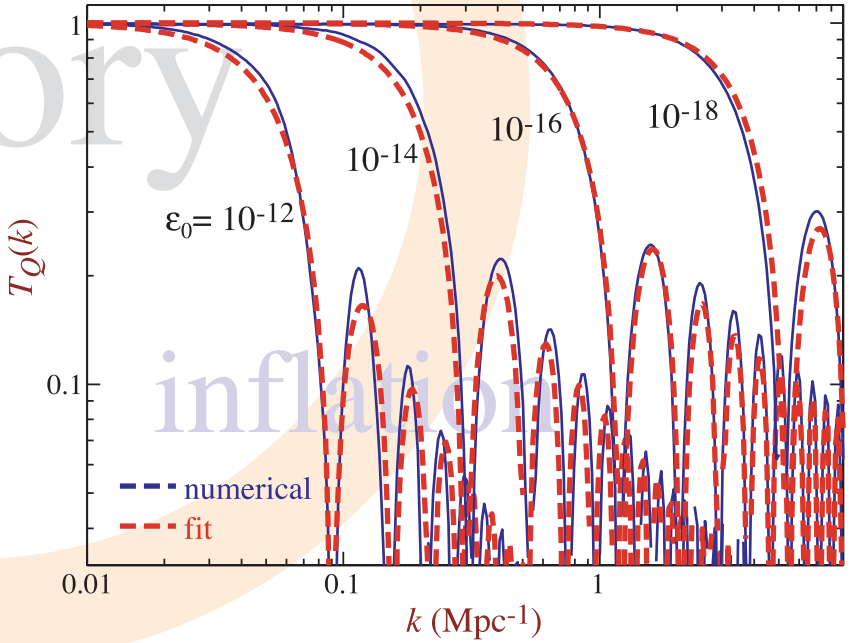




Dark Matter: Substructure

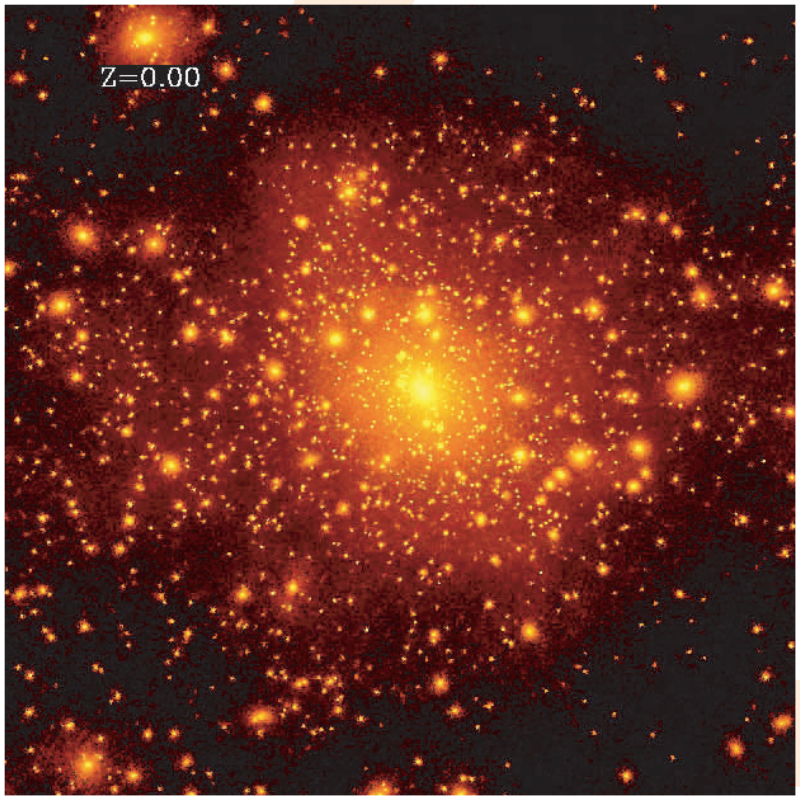
- Substructure constrains ghost condensate "unified" dark matter/energy Giannakis & Hu 2005

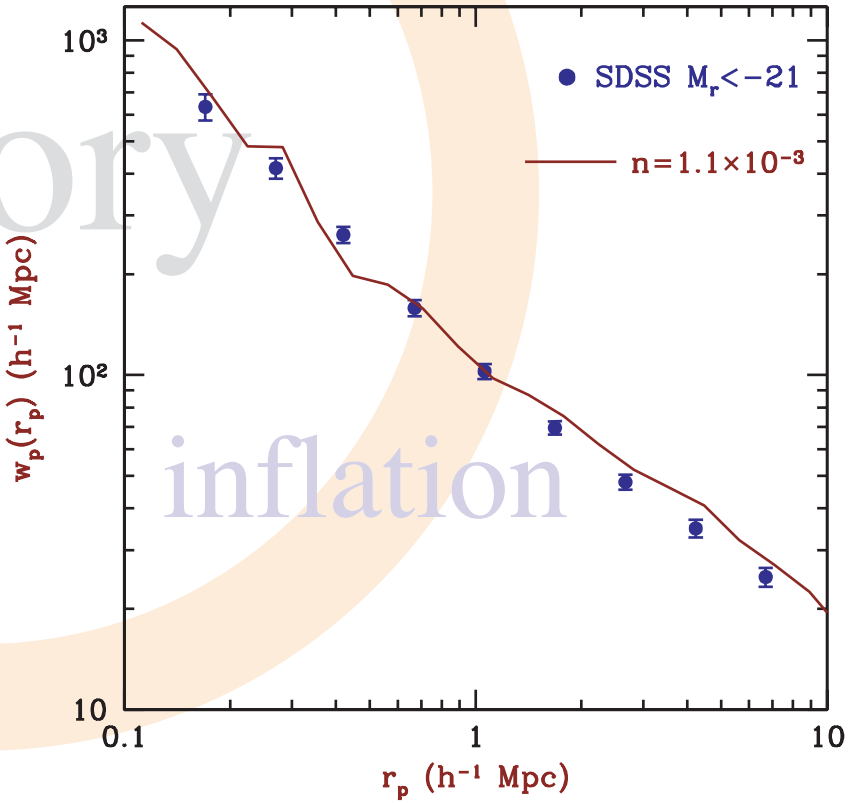




Dark Matter: Galaxy Clustering

- Associating galaxies with dark matter halos
  models galaxy clustering: SDSS, DEEP2, Subaru
  Zehavi et al (2004a,b); Kravtsov, Berlind, Wechsler (2004); Zentner et al (2005)
  Conroy, Wechsler, Kravtsov (2005)



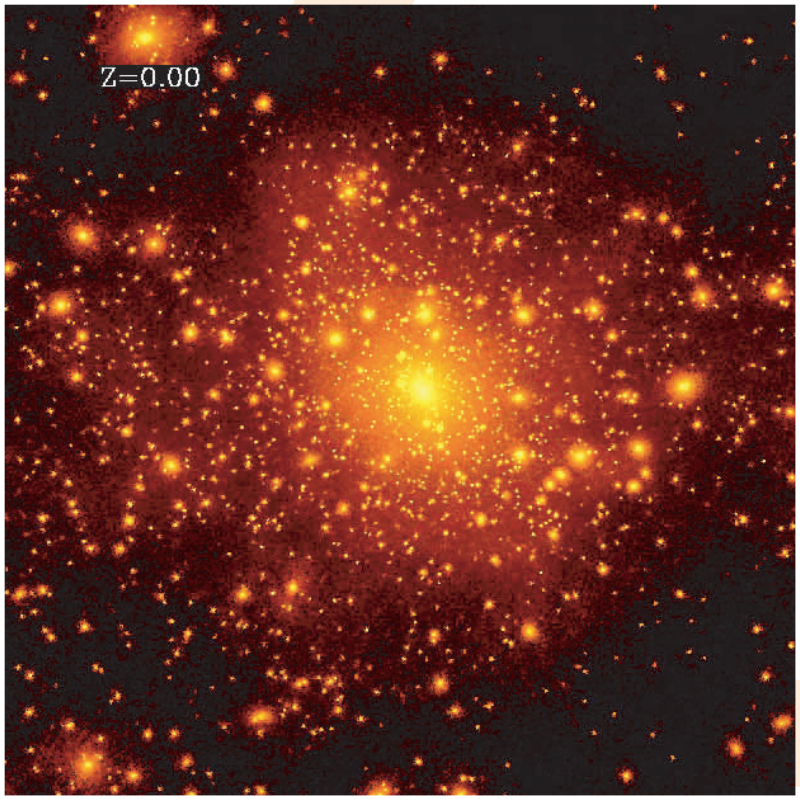


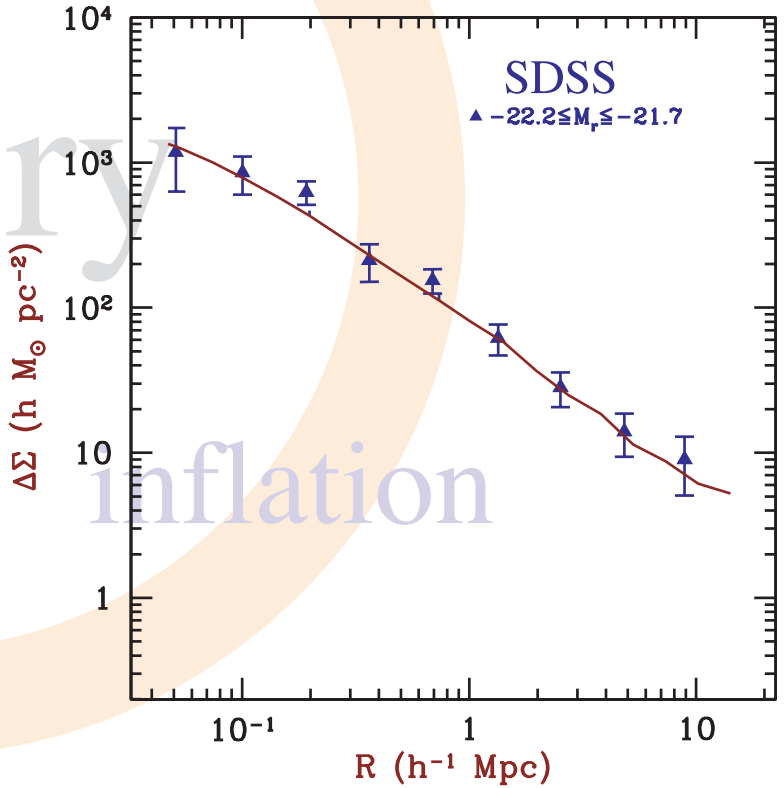
dark matter
ory
inflation

Dark Matter: Galaxy-Mass Correlation

- Modelling of galaxy-galaxy lensing through the halo substructure & galaxy mass correlation

  Sheldon et al (2003); Tasitiomi et al (2004); dark energy applications Hu & Jain (2004)

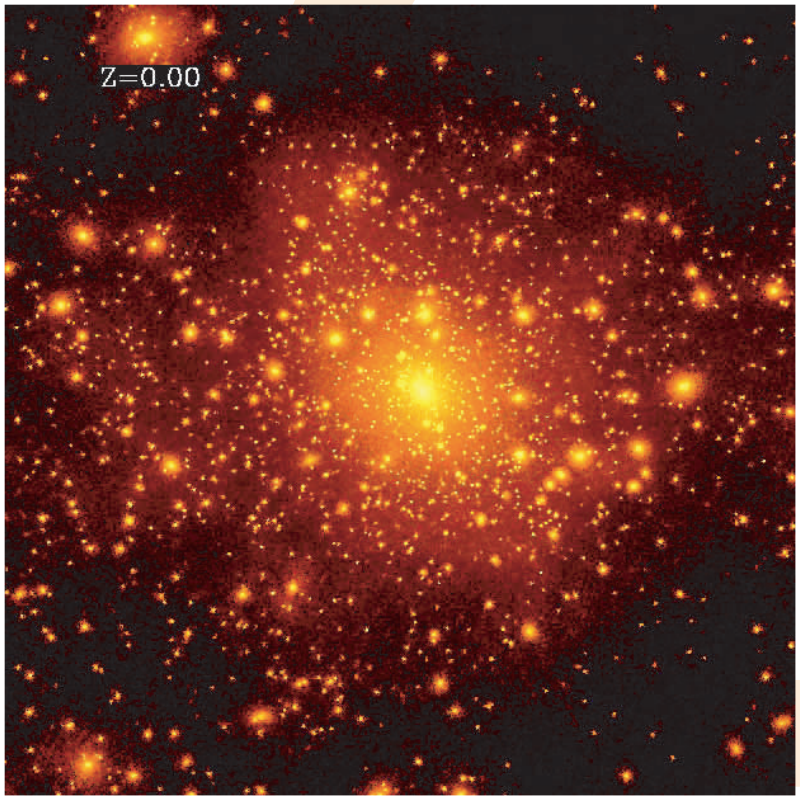


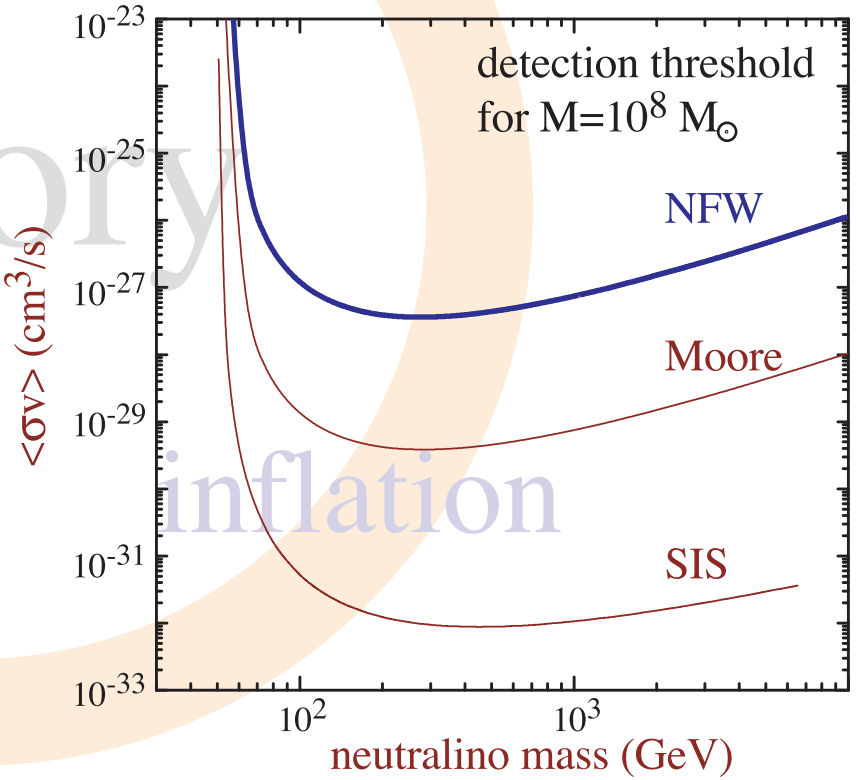


dark matter
ory
inflation

Dark Matter: Substructure

- Annihilation signature in substructure and galactic center? Blasi, Olinto, Tyler (2002); Tasitsiomi & Olinto (2002); Tasitsiomi, Gaskins, Olinto (2003a,b); Aloisio, Gaskins, Olinto (2004)



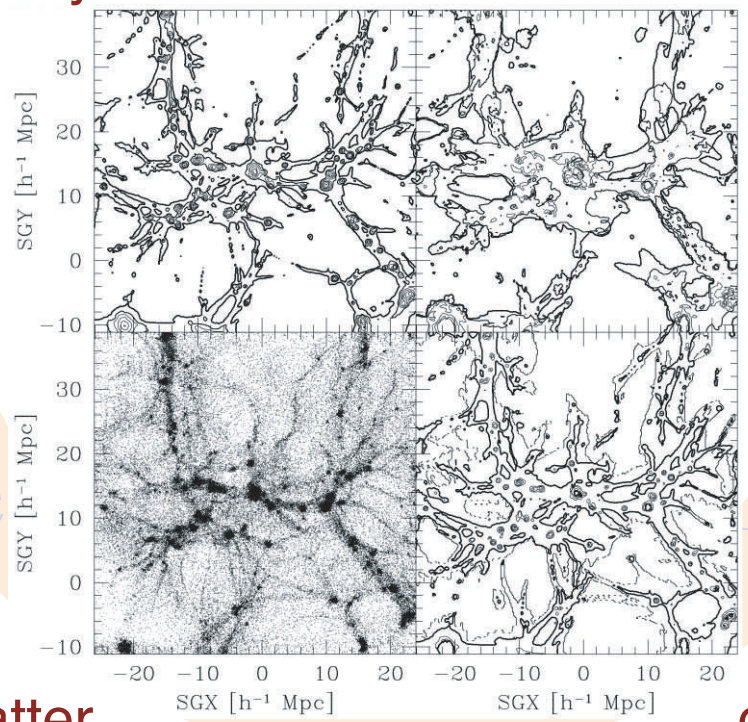


Dark Matter: Local Supercluster

- Constrained realizations of local supercluster and the UHECR Klypin, Hoffman, Kravtsov, Gottloeber (2001); Kravtsov, Klypin, Hoffman (2002) with CR propagation codes of Olinto (in progress)

gas density

temperature



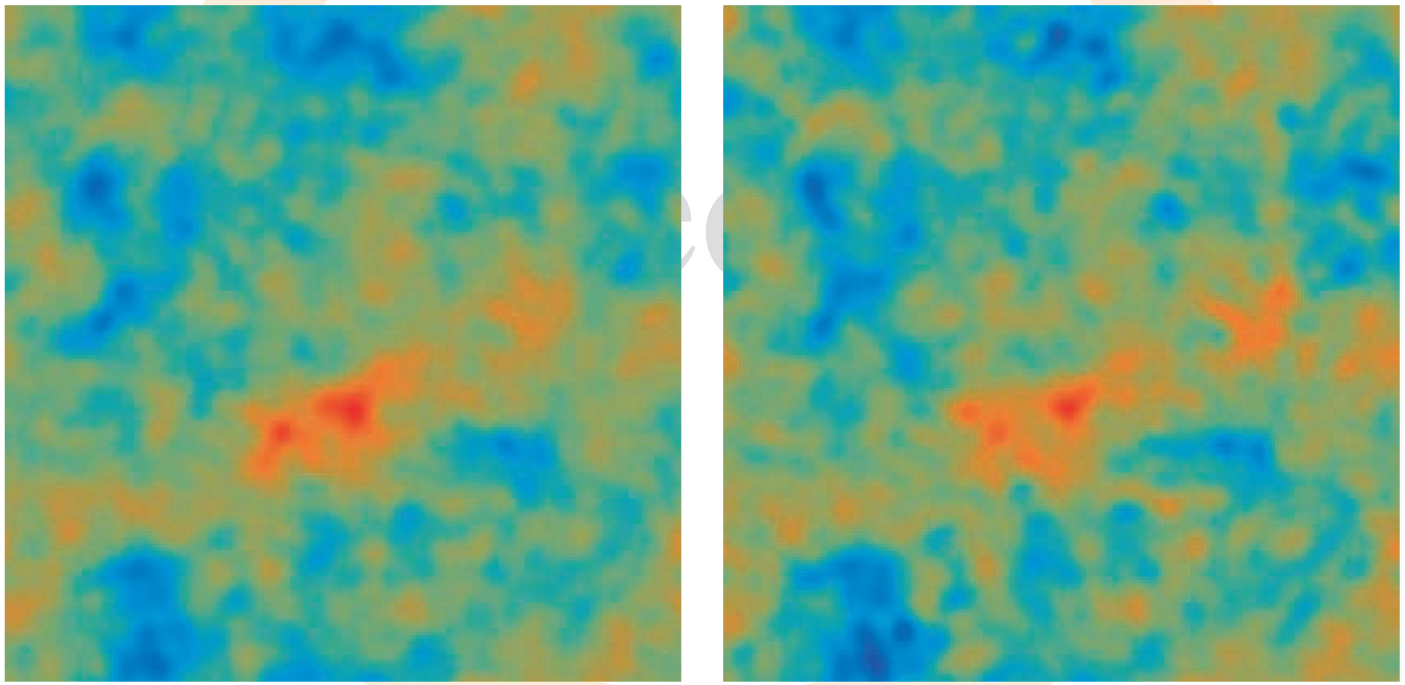
dark matter

gas phase

Dark Matter: CMB Lensing

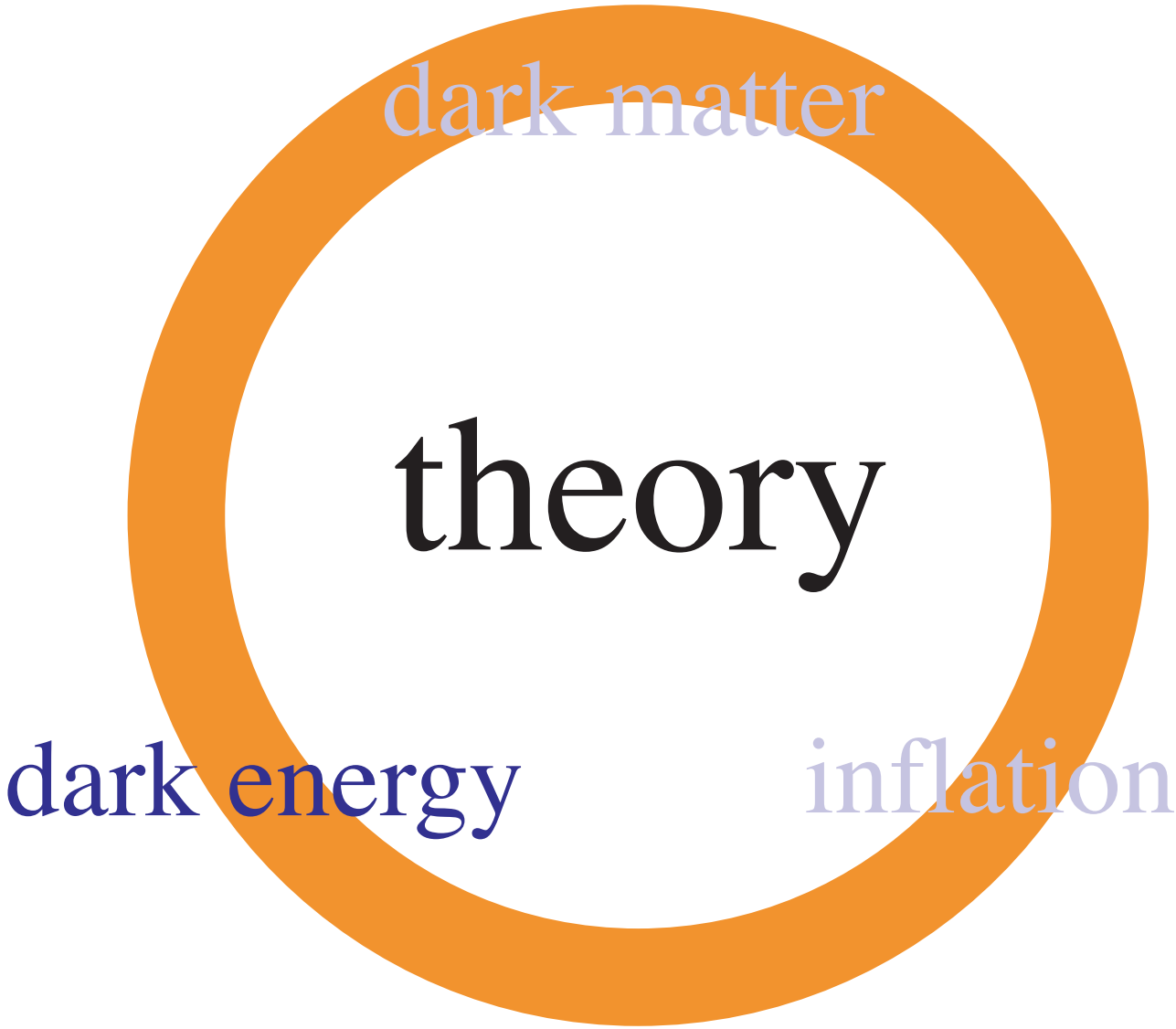
- Lensing of CMB by large scale structure: mass reconstruction, neutrino constraints

  Hu (2001); Hu & Okamoto (2002); Okamoto & Hu (2003); Smith, Hu Kaplinghat (2004)



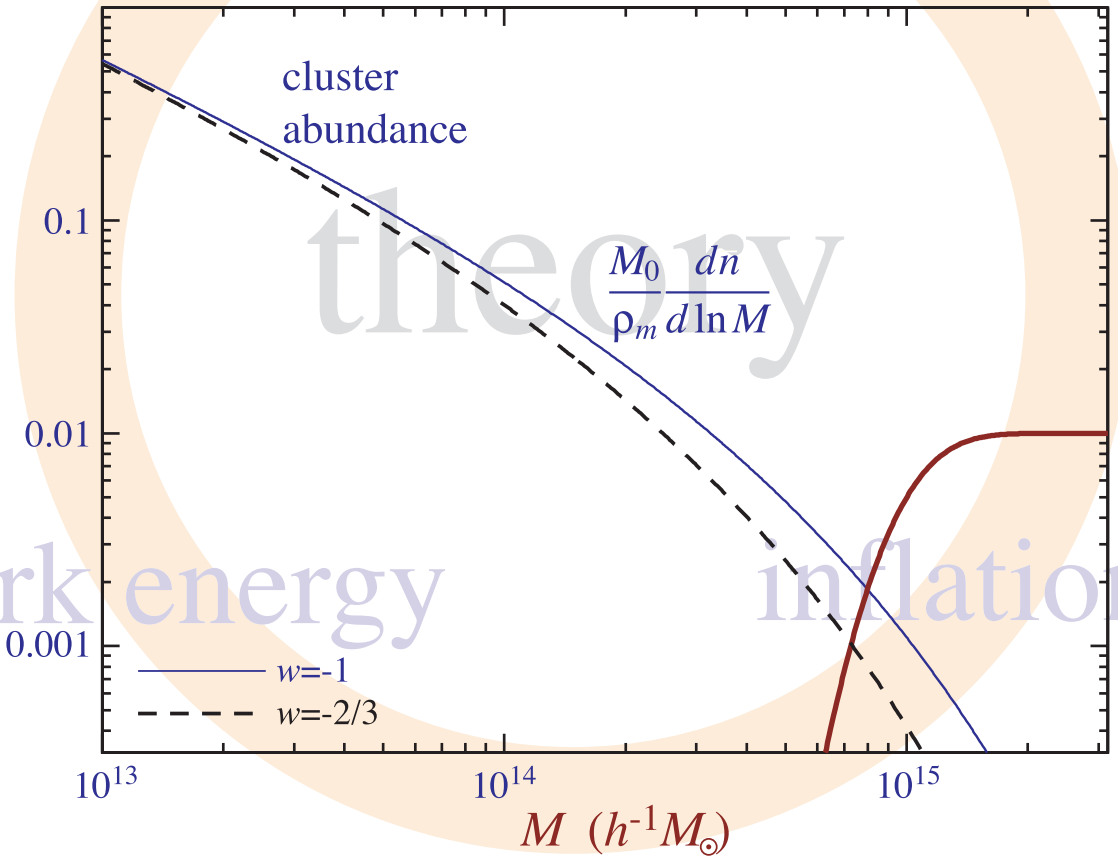
projected mass

reconstruction with polarization


dark matter
theory
dark energy
inflation

Dark Energy: Cluster Abundance

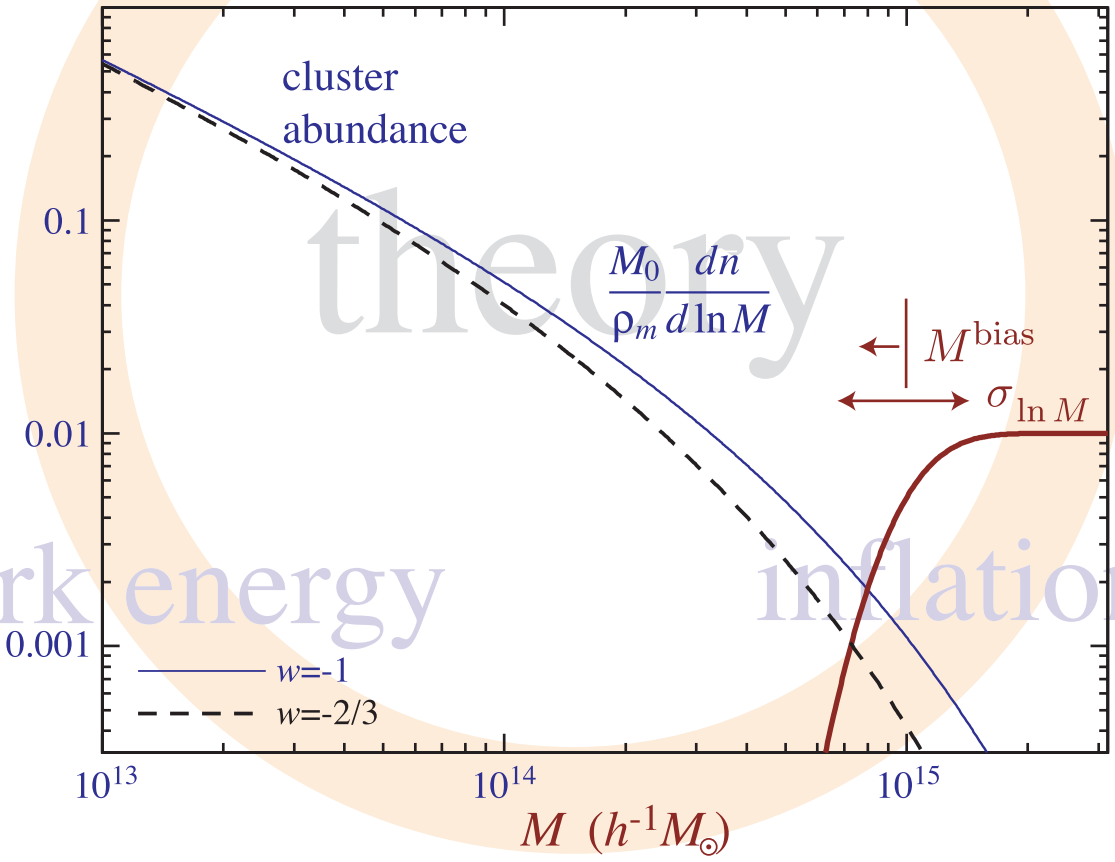
- Cluster counts above a given mass are exponentially sensitive to the dark energy



dark matter
theory
dark energy
inflation

Dark Energy: Cluster Abundance

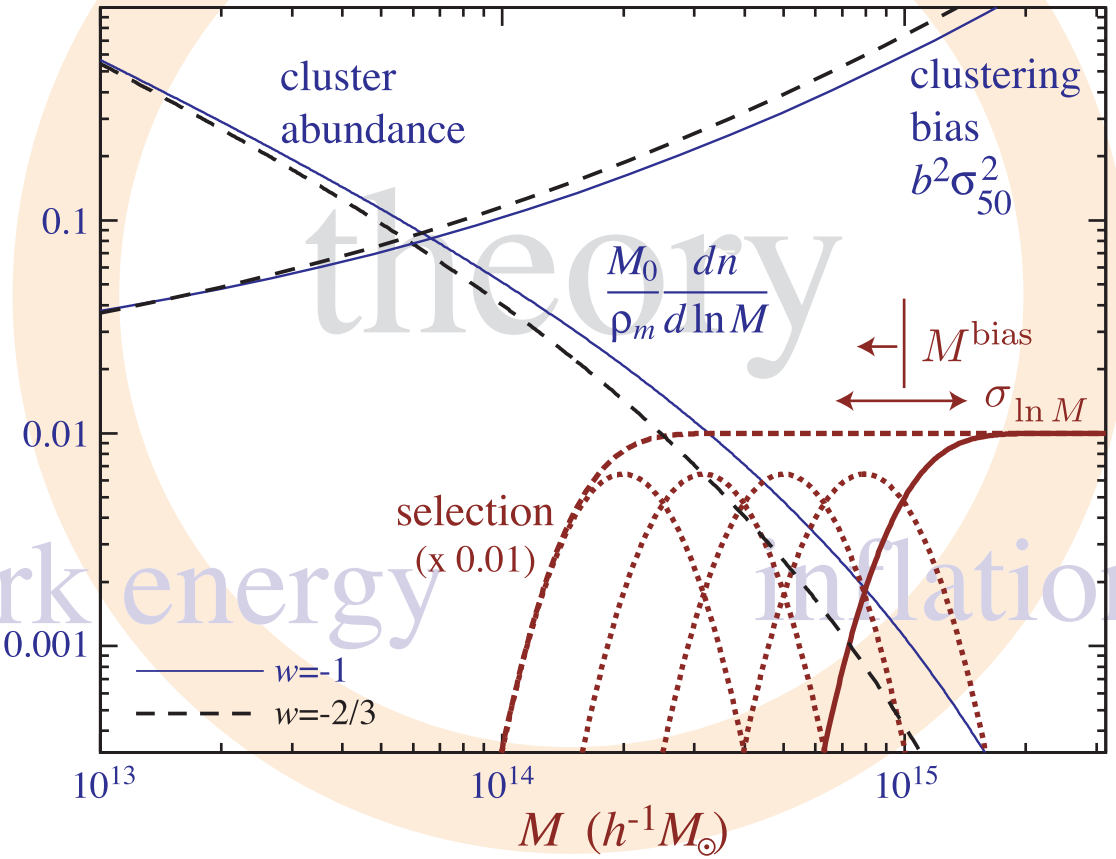
- Any uncertainty in the mass selection will degrade cosmological constraints



dark matter
theory
dark energy
inflation

Dark Energy: Cluster Abundance

- Internal consistency tests allow a degree of self-calibration Hu & Kravtsov (2002); Hu (2003); Lima & Hu (2004); Lima & Hu (2005); Johnston et al (2005)

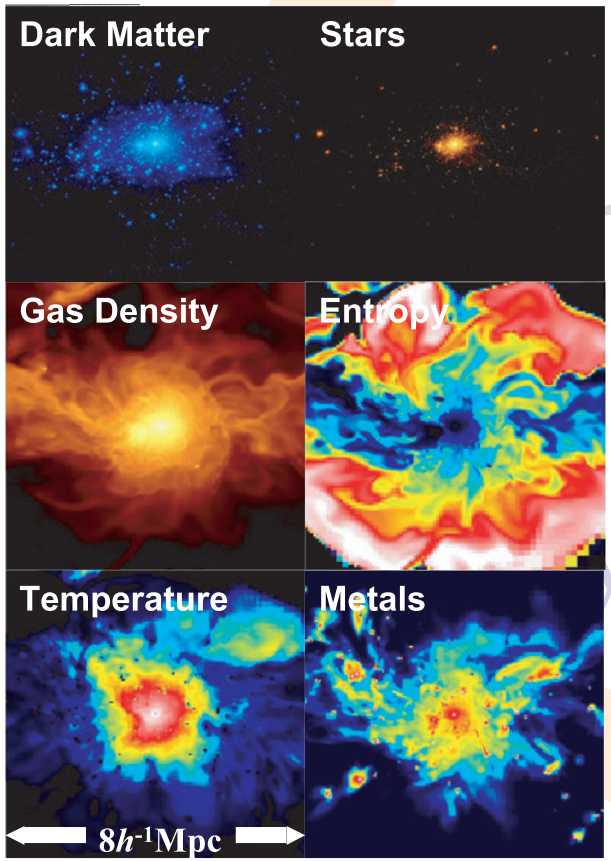


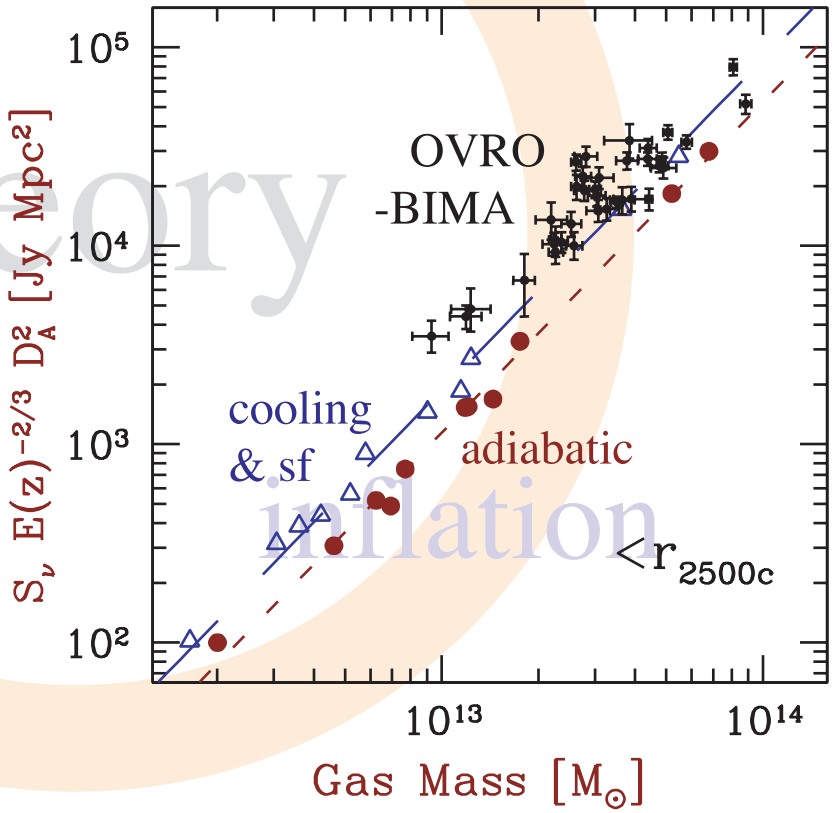
dark matter
theory
dark energy
inflation

Dark Energy: Cluster Abundance

- %-precision dark energy constraints requires deeper understanding of mass-observables

Kravtsov & Nagai (2005); Nagai (2005)

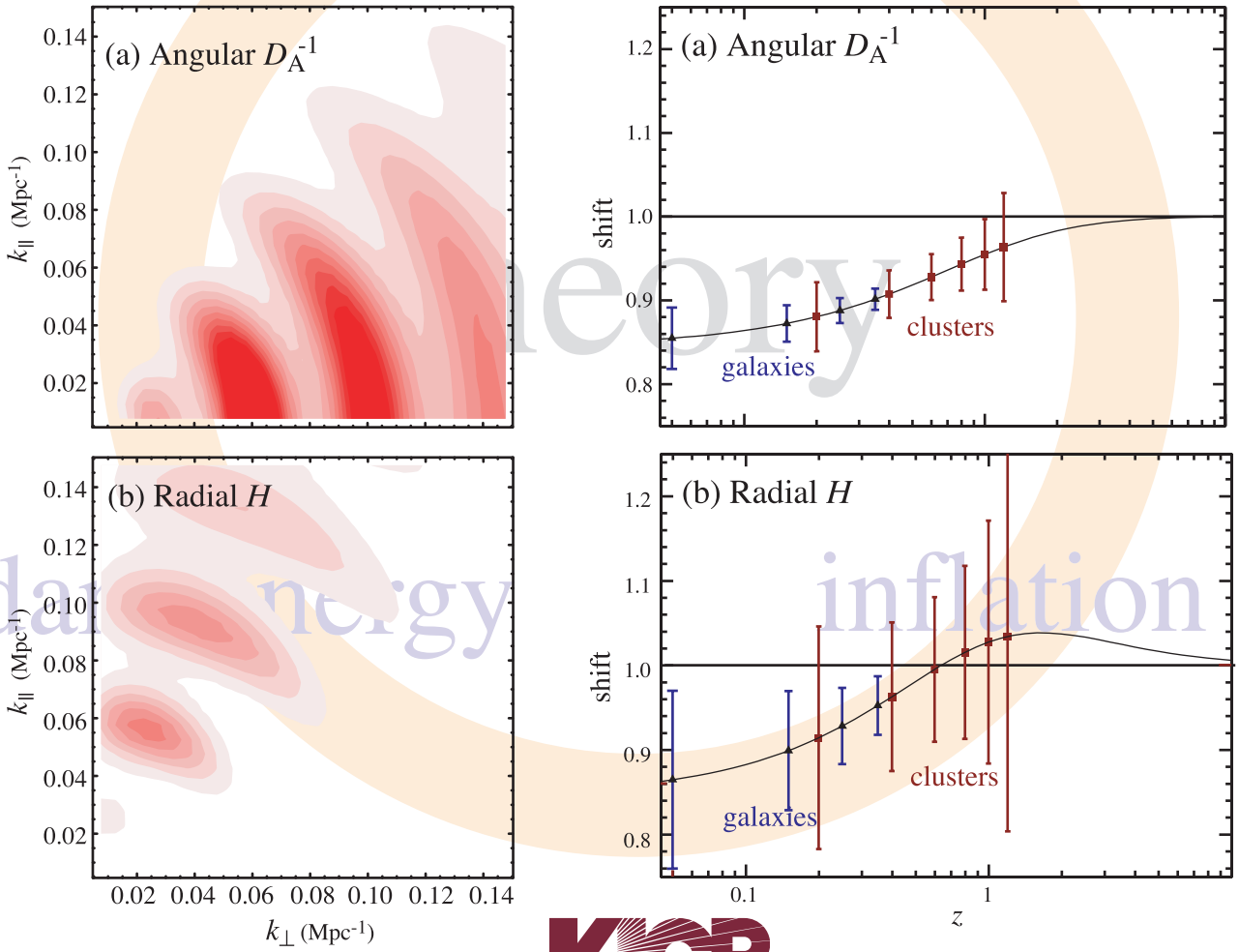




Dark Energy: Baryon Oscillations

- Baryon oscillations as standard ruler

  Eisenstein, Hu, Tegmark (1998); Cooray, Hu, Huterer, Joffre (2001); Hu, Haiman (2003)

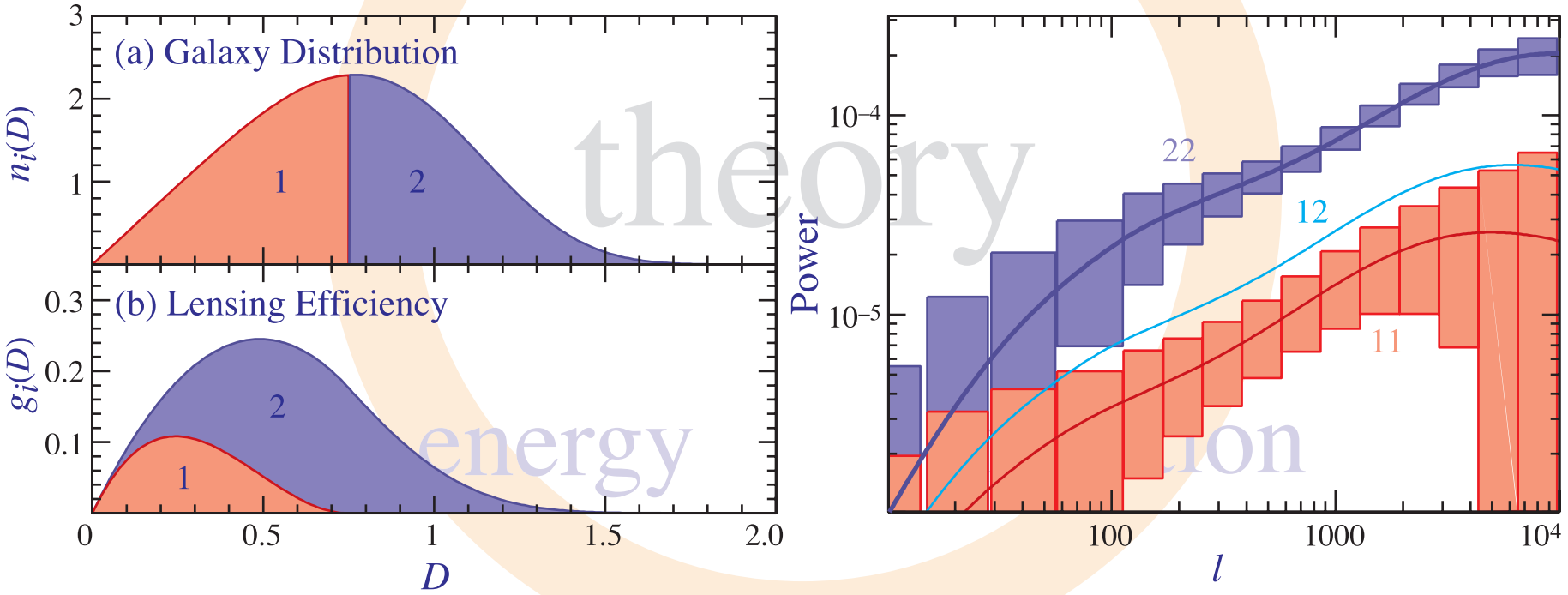


dark matter theory dark energy inflation

Dark Energy: Gravitational Lensing

- Gravitational lensing as a function of source redshift: tomographic growth and distances

Hu (1999)

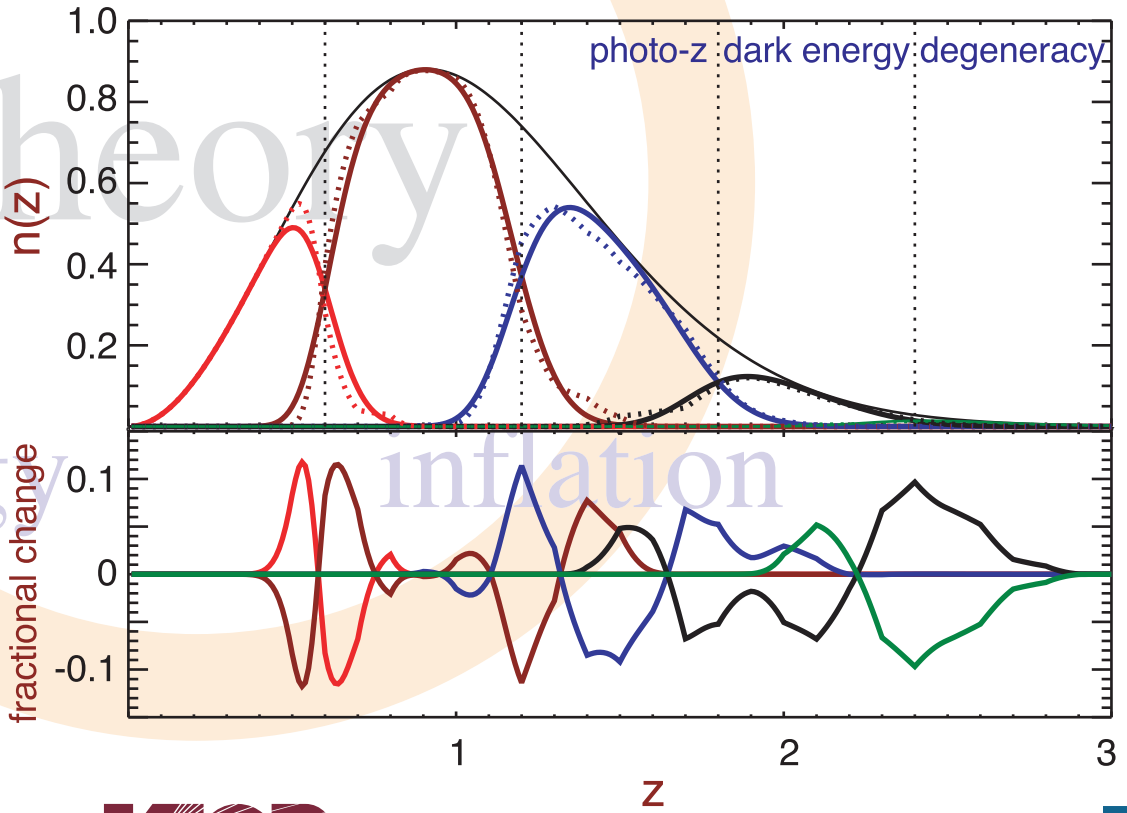


dark matter theory energy tion

Dark Energy: Gravitational Lensing

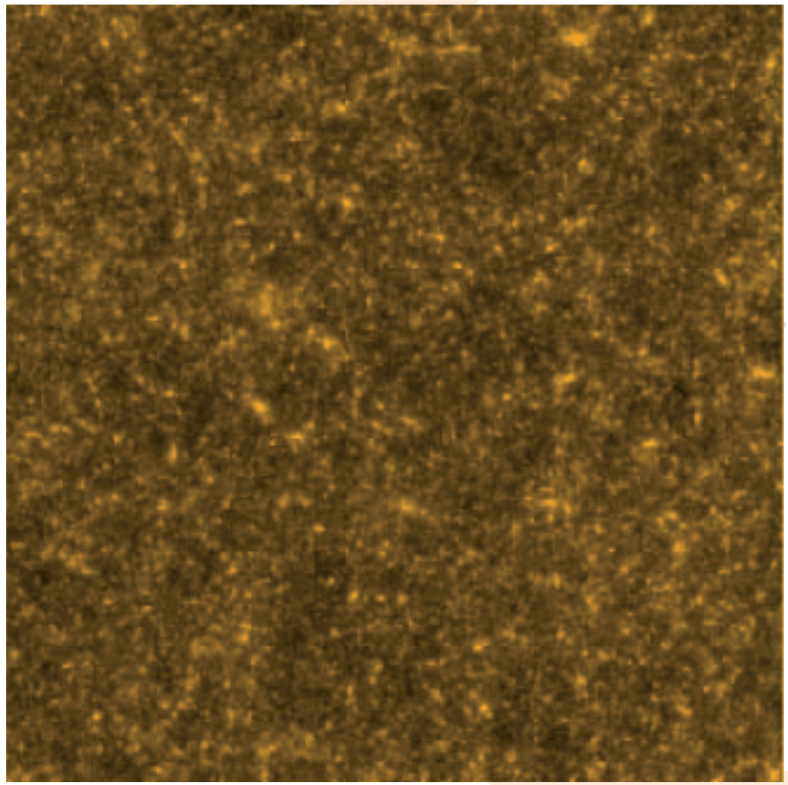
- Extensions: 3D mass mapping Hu & Keeton (2003); Hu (2003)
  correlations with CMB, galaxies Hu (2002); Hu & Jain (2004)
- Studies of systematic errors in astrophysical modelling and instrument

Huterer & Takada 2004;
Huterer & White 2005;
Hagan, Ma, Kravtsov 2005;
Huterer et al 2005;
Ma, Hu & Huterer 2005

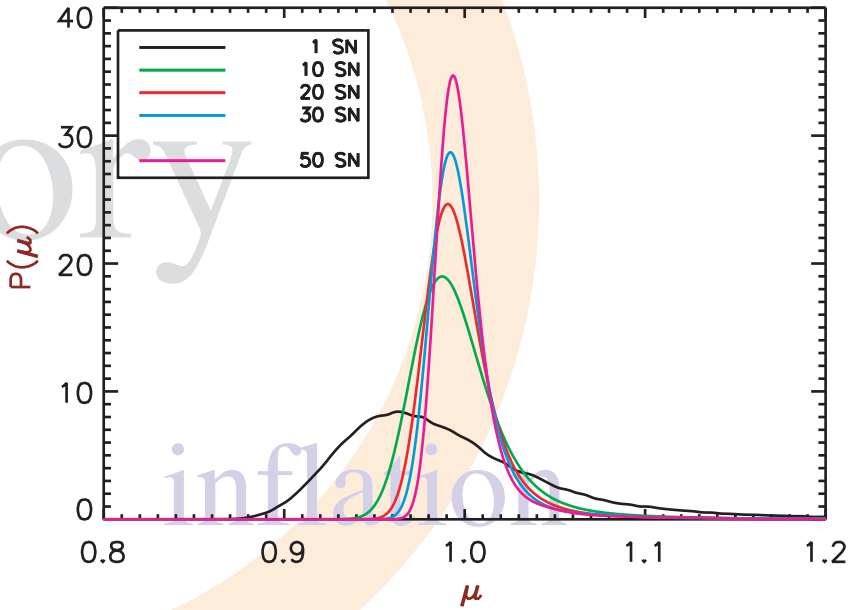


Dark Energy: Supernovae

- Gravitational lensing magnification of SNe
  Holz & Linder (2004); Cooray, Holz, Huterer (2005); Cooray, Huterer, Holz (2005)



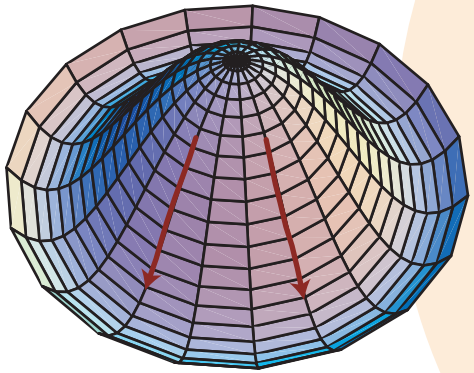
convergence



1pt magnitude distribution
2pt correlated by structure

Dark Energy: Theoretical Models

- Themes:



quintessence and inflation

[Gordon & Hu 2004; Gordon & Wands 2005; Rosenfeld & Frieman 2005]

phantom dark energy & k-essence

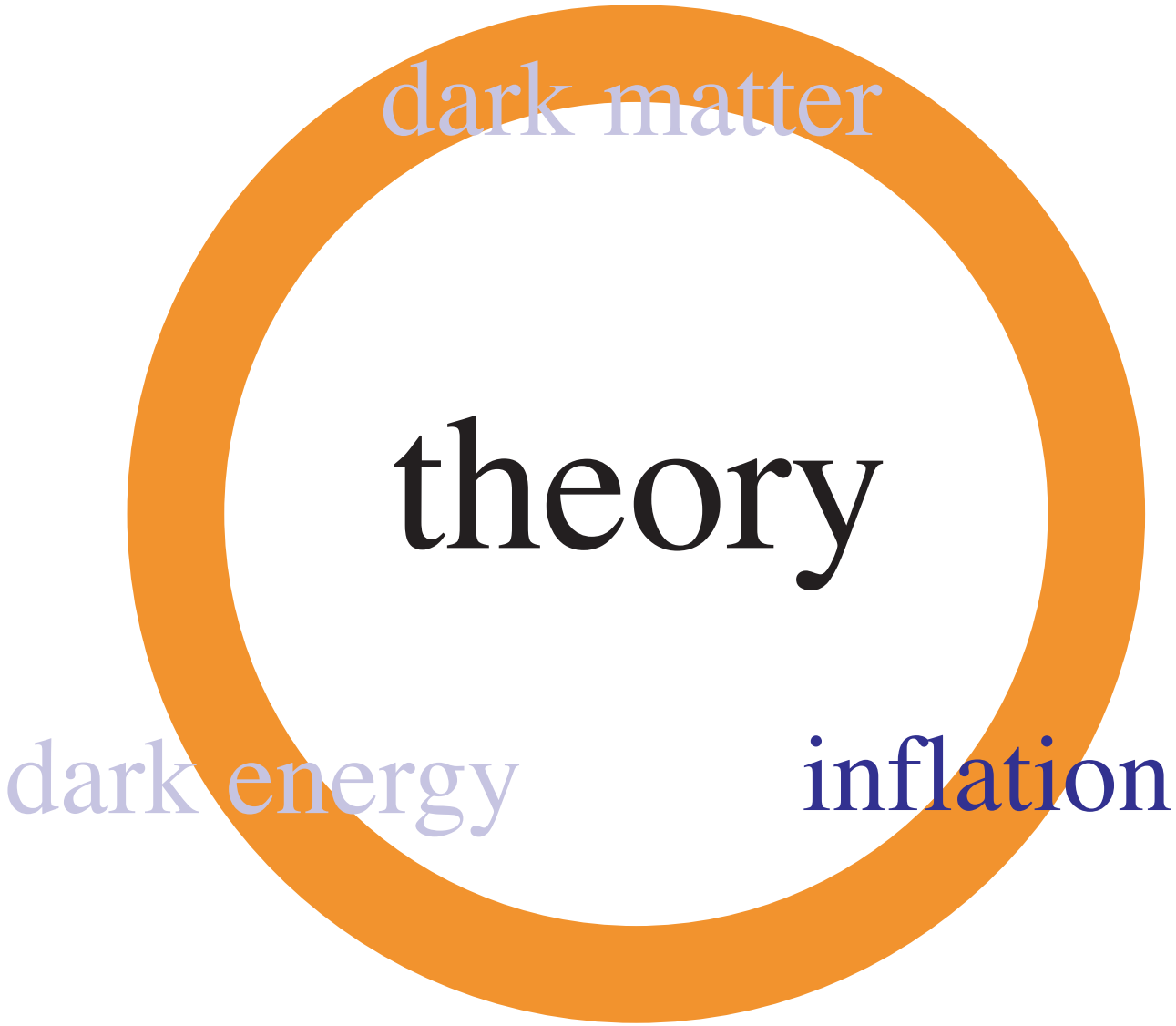
[Carroll, Hoffman & Trodden 2003; Hu 2004; Carroll, De Felice & Trodden 2005; Giannakis & Hu 2005]

spatial inhomogeneities

[Hu 2002; Hu & Okamoto 2002; Gordon & Hu 2004; Hu & Scranton 2004]

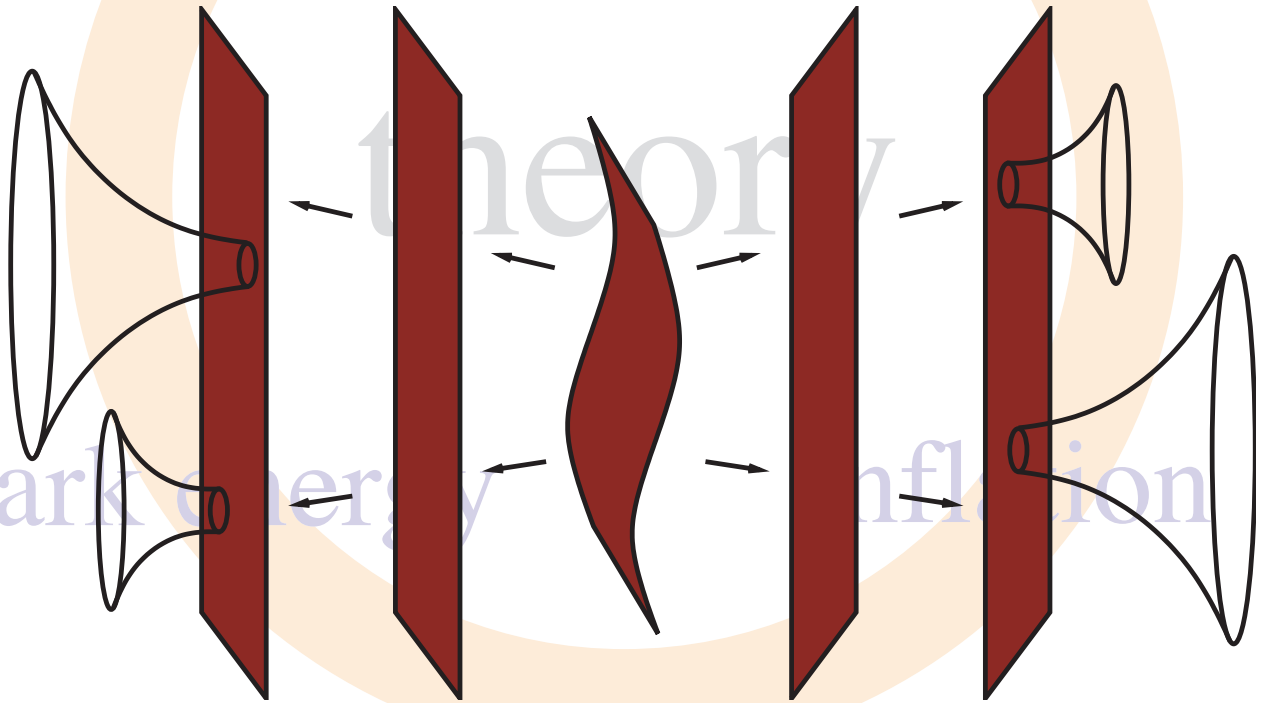
alternate explanations of acceleration

[Carroll et al. 2004; Carroll & Lim 2004; Carroll et al. 2005; Knox, Song,Tyson 2005; Song 2005; Song & Hu 2005 Sawicki & Carroll 2005]


dark matter
theory
dark energy
inflation

Inflation: Initial Conditions

- Low entropy initial conditions for inflation as thermal fluctuations in deSitter [Carroll & Chen 2005]

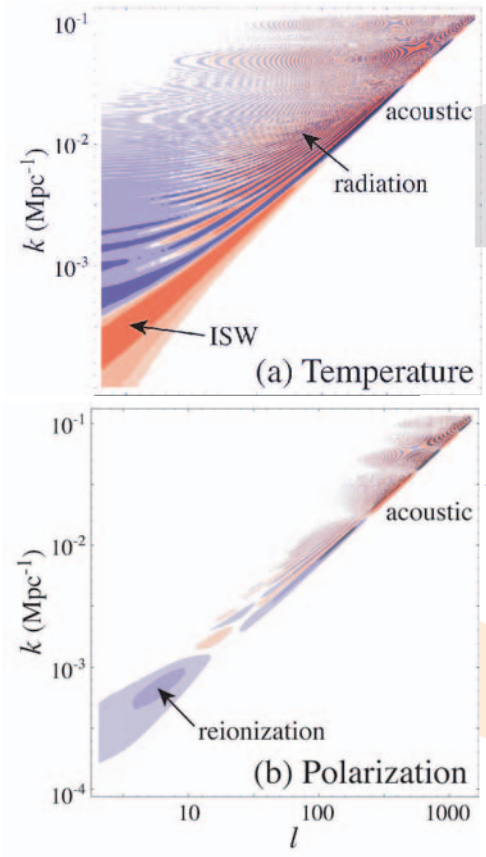


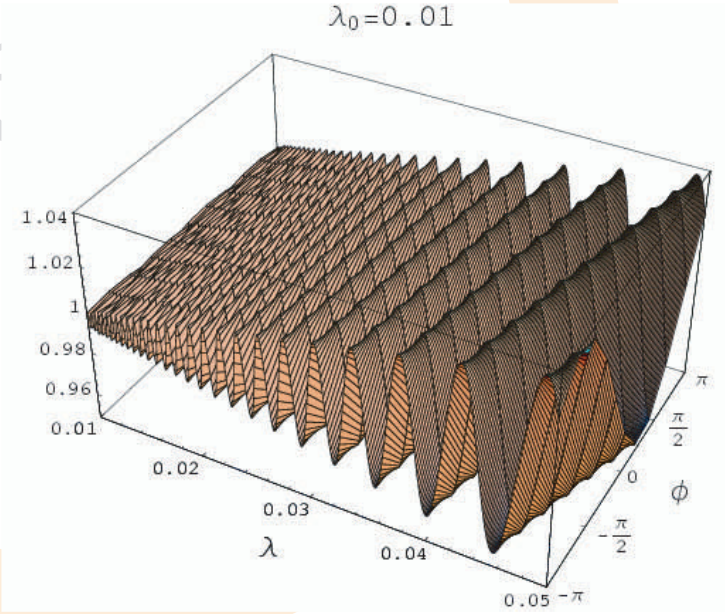
dark matter
theory
dark energy
inflation

Inflation: Features in P(k)

- Features in the potential and trans-planckian physics generates features in power spectrum

Hu & Okamoto (2004); Easther, Kinney & Peiris (2005a,b); Kadota, Dodelson, Hu Stewart (2005)

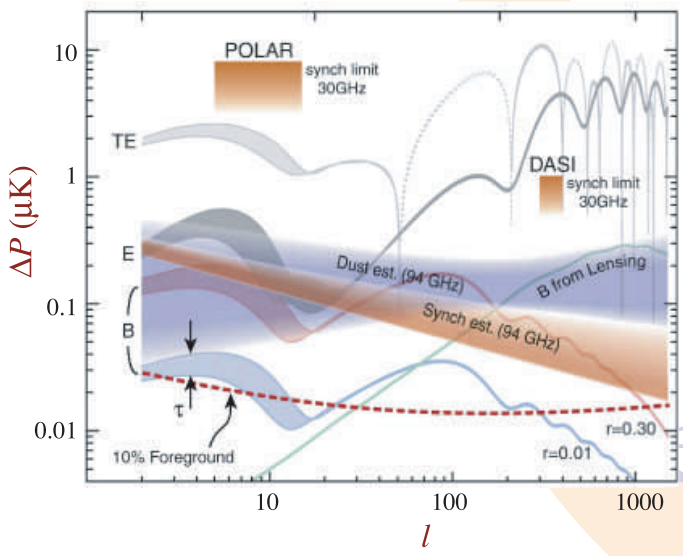


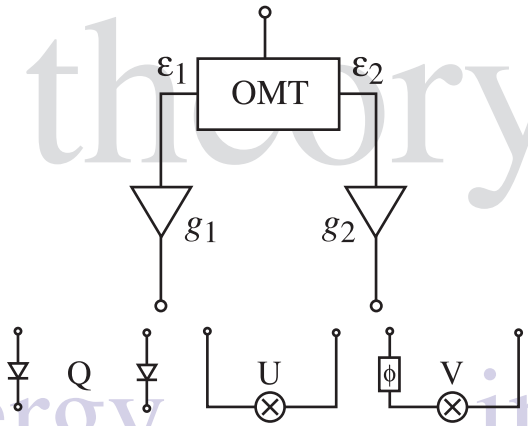


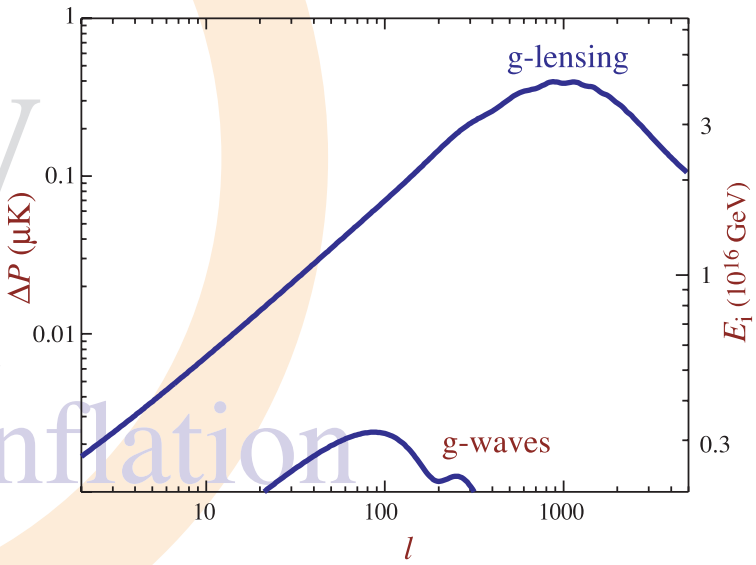
Inflation: Gravitational Waves

- Challenges for detecting gravitational waves

  Hu, Hedman, Zaldarriaga (2002); Hu & Okamoto (2002); Knox & Song (2003); Verde, Peiris, Jimenez (2005); Smith (2005)







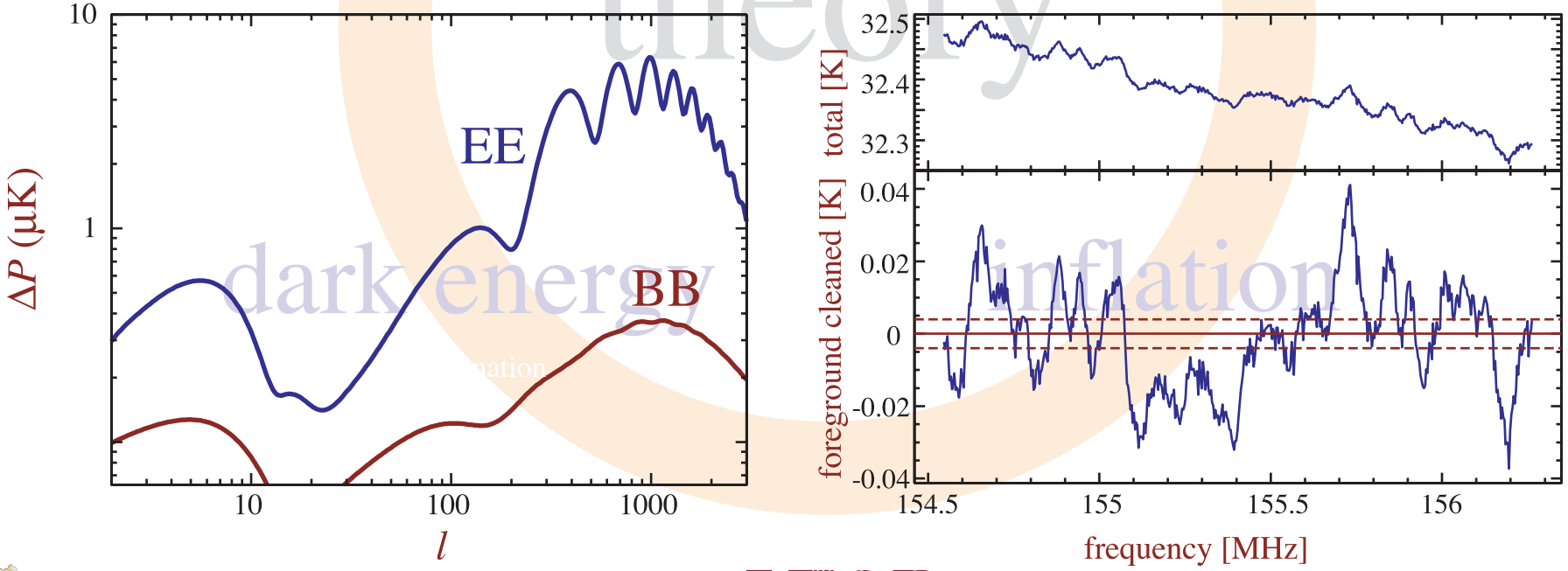
astrophysical instrumental cosmological

dark matter theory energy inflation

Inflation: Gravitational Waves

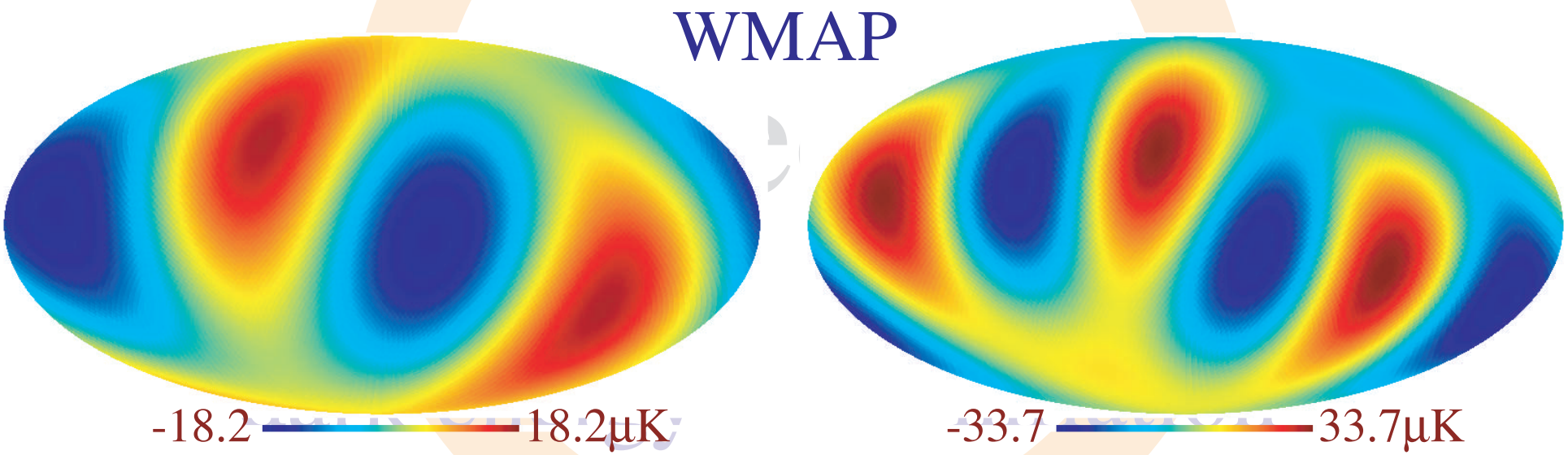
- Reionization potentially highest S/N gravitational wave B-modes - test scale invariance
- Interpretation requires study of reionization through e.g. E-mode spectrum, 21 cm emission

Hu & Holder (2004); Wang et al (2005); Wang & Hu (2005)



Inflation: Low Multipole Anomalies

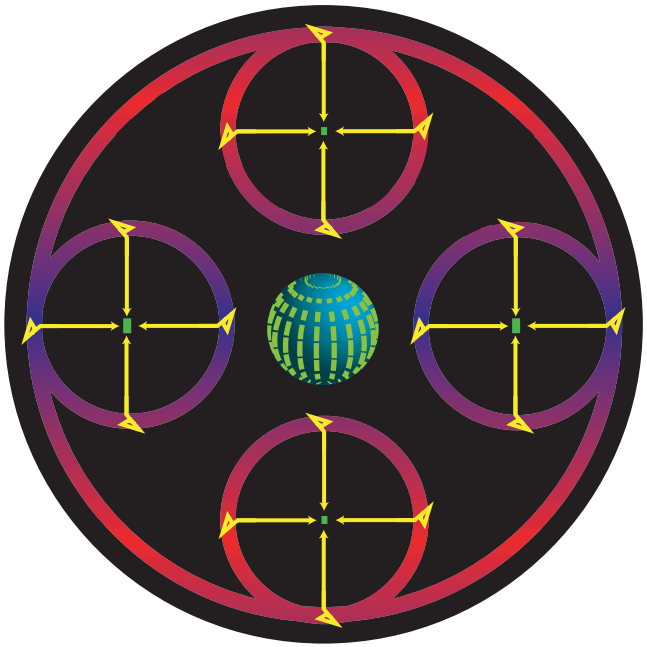
- Large angle alignments of CMB power deficits
  Schwarz, Starkman, Huterer, Copi (2004); Copi, Huterer, Schwarz, Starkman (2005)

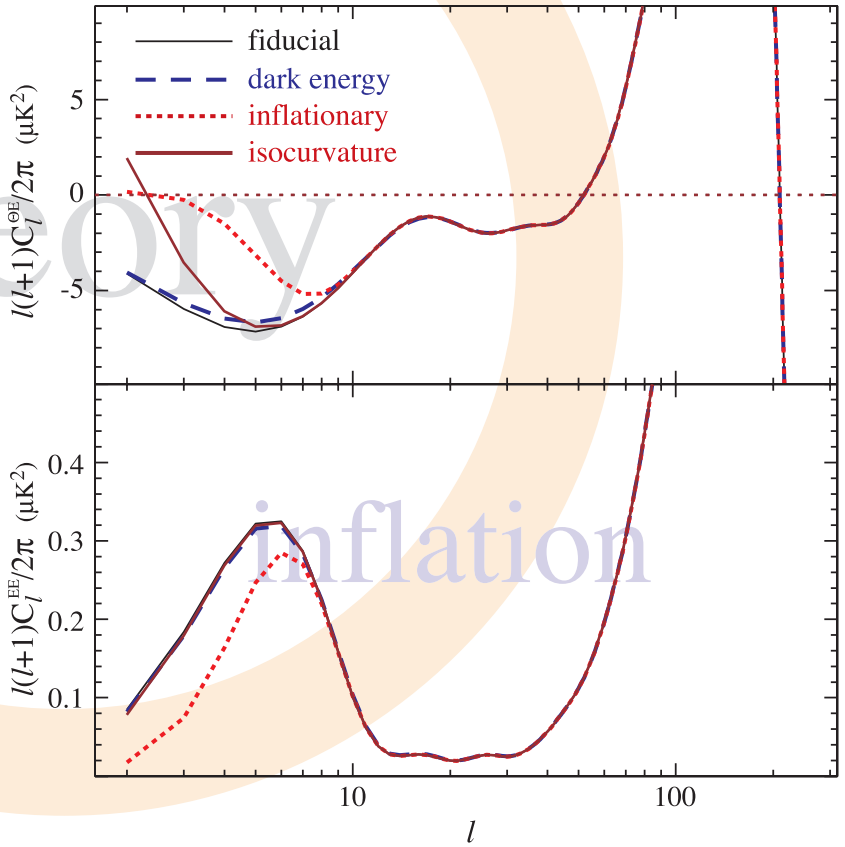


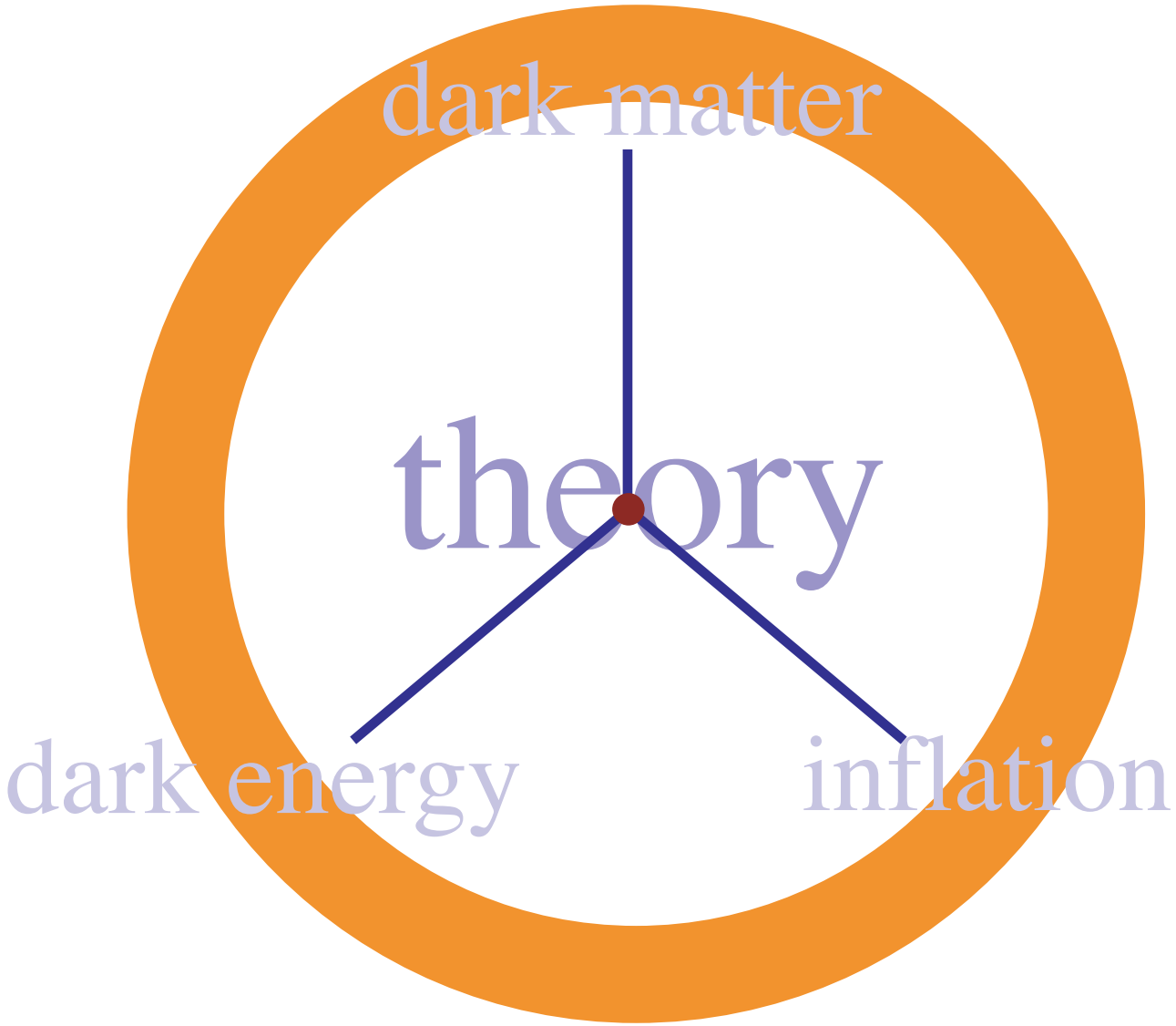
Inflation: Low Multipole Anomalies

- Modulated inflationary initial conditions vs dark energy distinguished by polarization

  Gordon & Hu (2004); Gordon, Hu, Huterer, Crawford (2005)

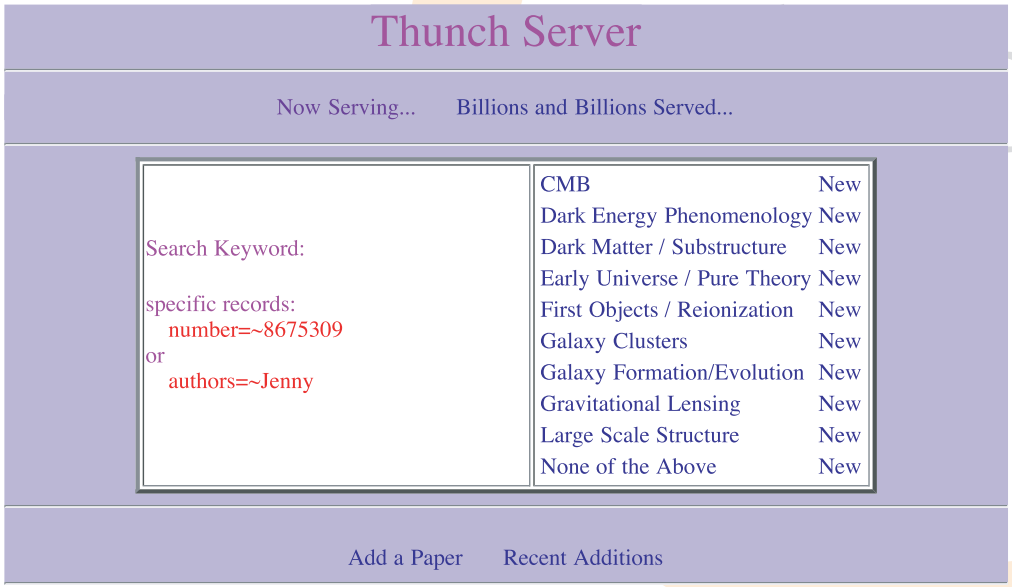




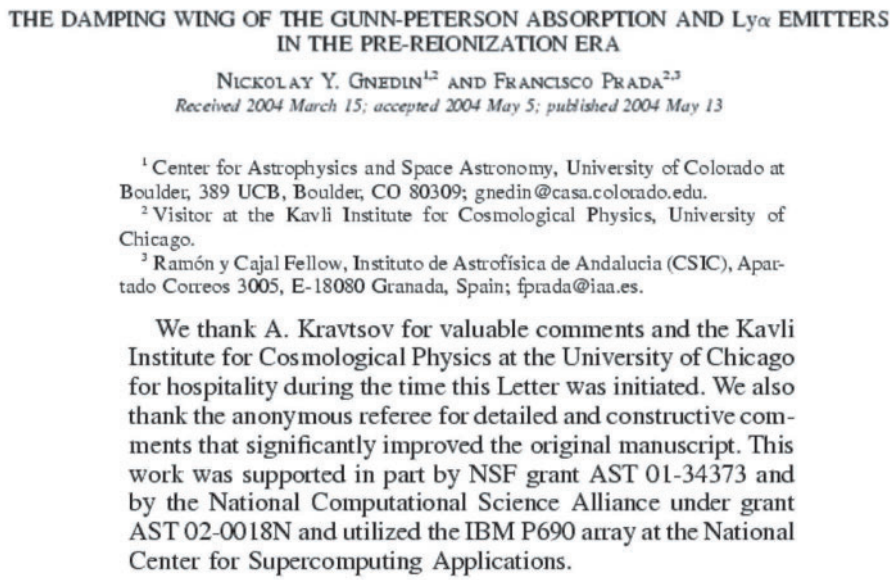

dark matter
theory
dark energy
inflation

Theory: Intangibles

- Close interactions with experimentalists
- Training ground for postdocs and students
- Broader impact of visitors program, workshops



theorist-experimentalist



THE DAMPING WING OF THE GUNN-PETERSON ABSORPTION AND Lyα EMITTERS IN THE PRE-REIONIZATION ERA

NICKOLAY Y. GNEDIN[1,2] AND FRANCISCO PRADA[2,3]

Received 2004 March 15; accepted 2004 May 5; published 2004 May 13

[1] Center for Astrophysics and Space Astronomy, University of Colorado at Boulder, 389 UCB, Boulder, CO 80309; gnedin@casa.colorado.edu.
[2] Visitor at the Kavli Institute for Cosmological Physics, University of Chicago.
[3] Ramón y Cajal Fellow, Instituto de Astrofísica de Andalucia (CSIC), Apartado Correos 3005, E-18080 Granada, Spain; fprada@iaa.es.

We thank A. Kravtsov for valuable comments and the Kavli Institute for Cosmological Physics at the University of Chicago for hospitality during the time this Letter was initiated. We also thank the anonymous referee for detailed and constructive comments that significantly improved the original manuscript. This work was supported in part by NSF grant AST 01-34373 and by the National Computational Science Alliance under grant AST 02-0018N and utilized the IBM P690 array at the National Center for Supercomputing Applications.

visitor-visitor

Theory: Intangibles

- Close interactio rimentalists
- Training gr d for postdocs l students
- Broader pact of visitors progra workshops

theory

dark matter

dark energy

inflation

theorist-experimentali

visitor-visitor