Astrophysics Theory & Center

Long Range Planning Committee
October 14, 2003

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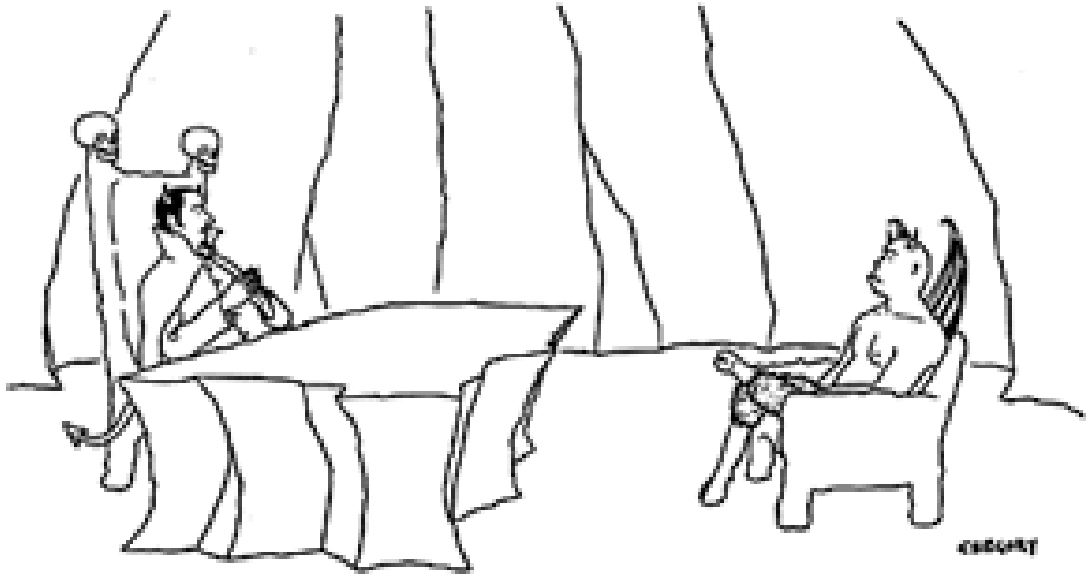

"I need someone well versed in the art of torture—do you know PowerPoint?"

Non-Baryonic Dark Matter

THE ASTROPHYSICAL JOURNAL, 223:1015–1031, 1978 August 1
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SOME ASTROPHYSICAL CONSEQUENCES OF THE EXISTENCE OF A HEAVY STABLE NEUTRAL LEPTON

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ABSTRACT

Recently, high-energy particle theorists have constructed new extended gauge theories which may fit experiment somewhat better than previous already very successful theories. One of the predictions which is often discussed is the possible existence of a stable neutral lepton, probably with a mass of a few GeV/c^2. Following this motivation we here investigate some cosmological consequences of the existence of *any* stable, massive, neutral lepton, and show that it could well dominate the present mass density in the universe. The contribution to the mass density depends on the mass of the lepton, which should eventually be determined with high-energy accelerators. It is interesting that the more massive the lepton, the smaller its contribution to the present mass density. It is unlikely that these leptons affect big bang nucleosynthesis or condense into stellar size objects. However, such a lepton is an excellent candidate for the material in galactic halos and for the mass required to bind the great clusters of galaxies. Annihilation radiation from these structures should be detectable. At the end of the paper a brief mention is made of the astrophysical constraints on the mass-lifetime relationship if the neutral lepton is unstable.

Subject headings: cosmology — elementary particles

Rotation Velocities

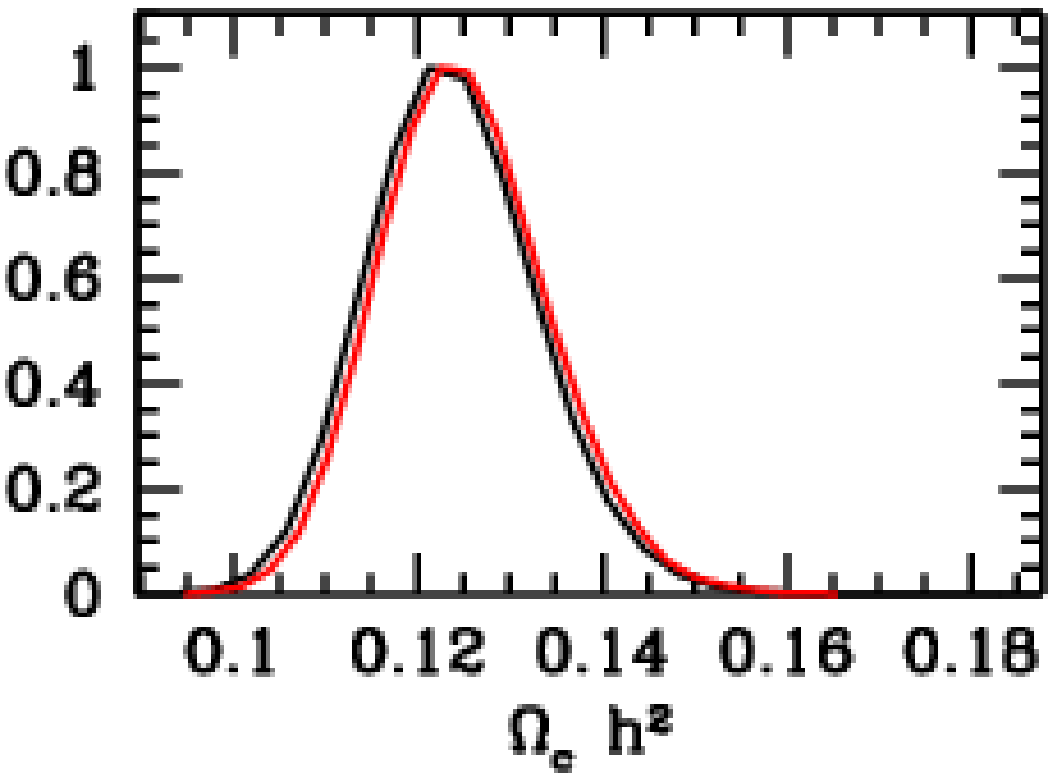
Galaxy Clusters

Accelerator Production

Local Abundance

Light Element Abundances

Non-Baryonic Dark Matter



Cold Dark Matter Density

SDSS+WMAP: Abazajian, 2003

- Rotation Velocities
- Galaxy Clusters
- Accelerator Production
- Local Abundance
- Light Element Abundances
- Matter Distribution in Universe
- CMB Anisotropies

Inflation

Matter Distribution in Universe

CMB Anisotropies

PHYSICAL REVIEW D
PARTICLES AND FIELDS

THIRD SERIES, VOLUME 28, NUMBER 4 15 AUGUST 1983

Spontaneous creation of almost scale-free density perturbations in an inflationary universe

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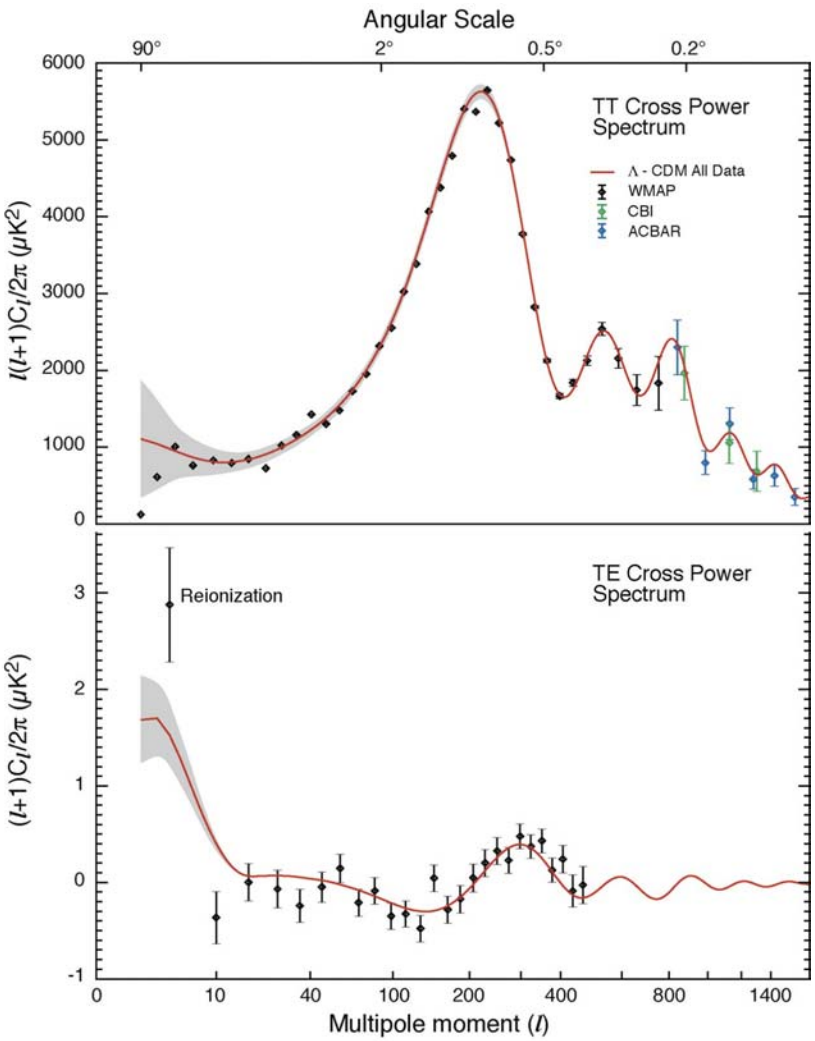
(Received 31 March 1983)

Inflation



Bennett et al., 2003

Matter Distribution in Universe

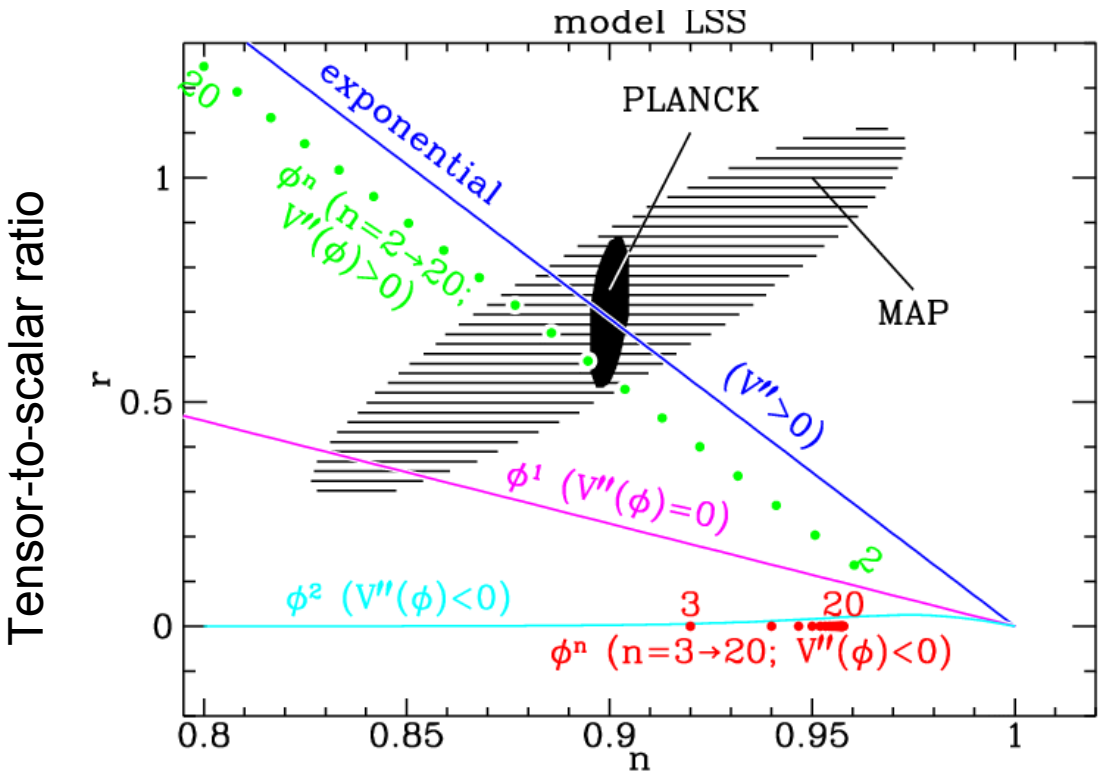
CMB Anisotropies

Inflation

Matter Distribution in Universe

CMB Anisotropies

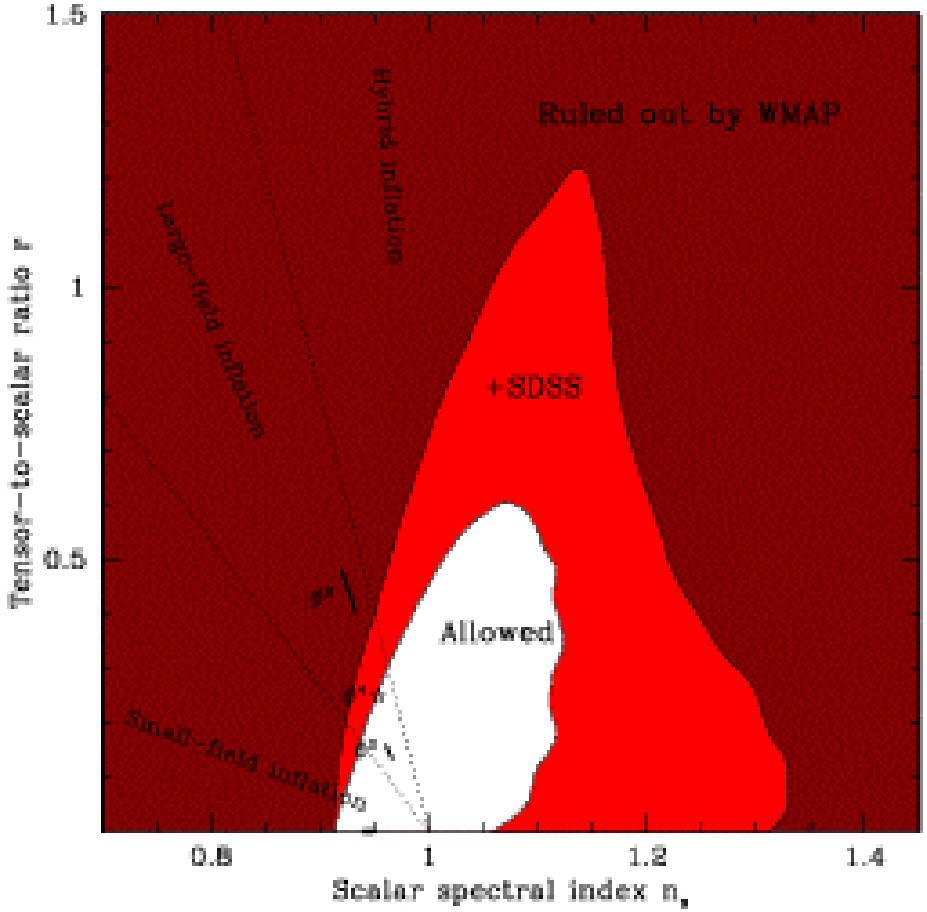
Gravity Waves: Tensor modes



Scalar Spectral Index

Dodelson, Kinney, & Kolb 1997

Inflation



SDSS: Tegmark, Abazajian, Dodelson et al. 2003

Matter Distribution in Universe

CMB Anisotropies

Gravity Waves: Tensor modes

Dark Energy

Galaxy Clusters

Matter Distribution in Universe

: 75, NUMBER 11 PHYSICAL REVIEW LETTERS 11 SEPTEMBER 1995

Cosmology with Ultralight Pseudo Nambu-Goldstone Bosons

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(Received 17 May 1995)

We explore the cosmological implications of an ultralight pseudo Nambu-Goldstone boson. With global spontaneous symmetry breaking scale $f \simeq 10^{18}$ GeV and explicit breaking scale comparable to Mikheyev-Smirnov-Wolfenstein neutrino masses, $M \sim 10^{-3}$ eV, such a field, which acquires a mass $m_\phi \sim M^2/f \sim H_0$, would currently dominate the energy density of the Universe. The field acts as an effective cosmological constant before relaxing into a condensate of nonrelativistic bosons. Such a model can reconcile dynamical estimates of the density parameter, $\Omega_m \sim 0.2$, with a spatially flat universe, yielding $H_0 t_0 \simeq 1$ consistent with limits from gravitational lens statistics.

PACS numbers: 98.80.Cq, 14.80.Mz, 98.70.Vc

Dark Energy

Galaxy Clusters

Matter Distribution in Universe

CMB Anisotropies

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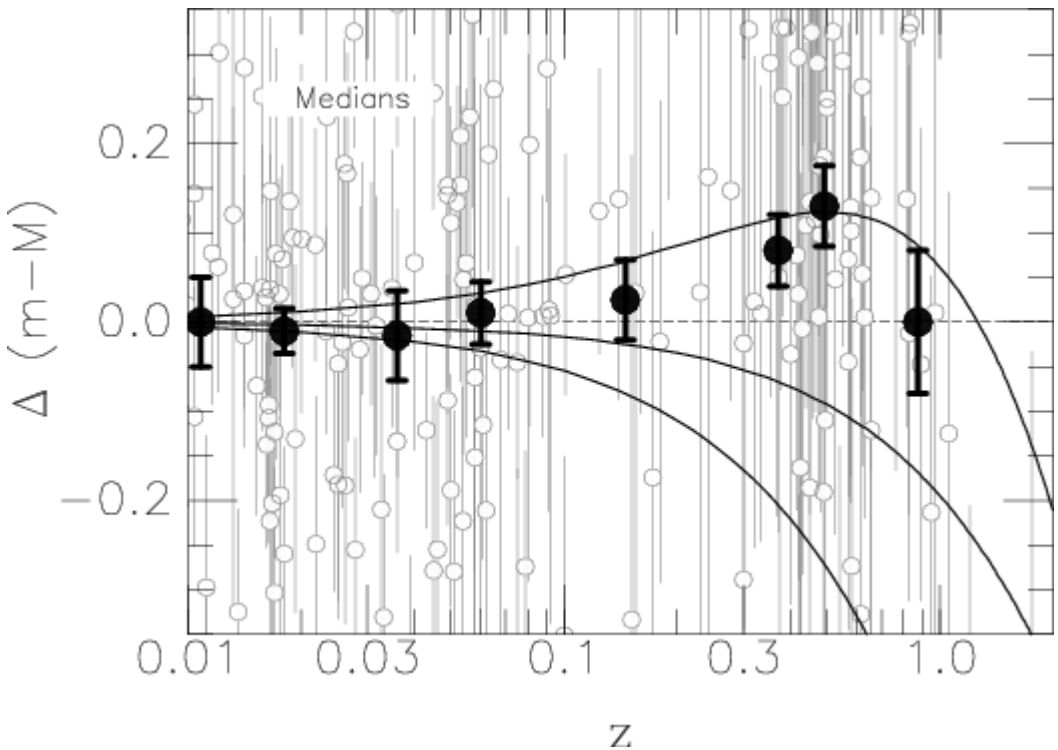
Dark Energy

Galaxy Clusters

Matter Distribution in Universe

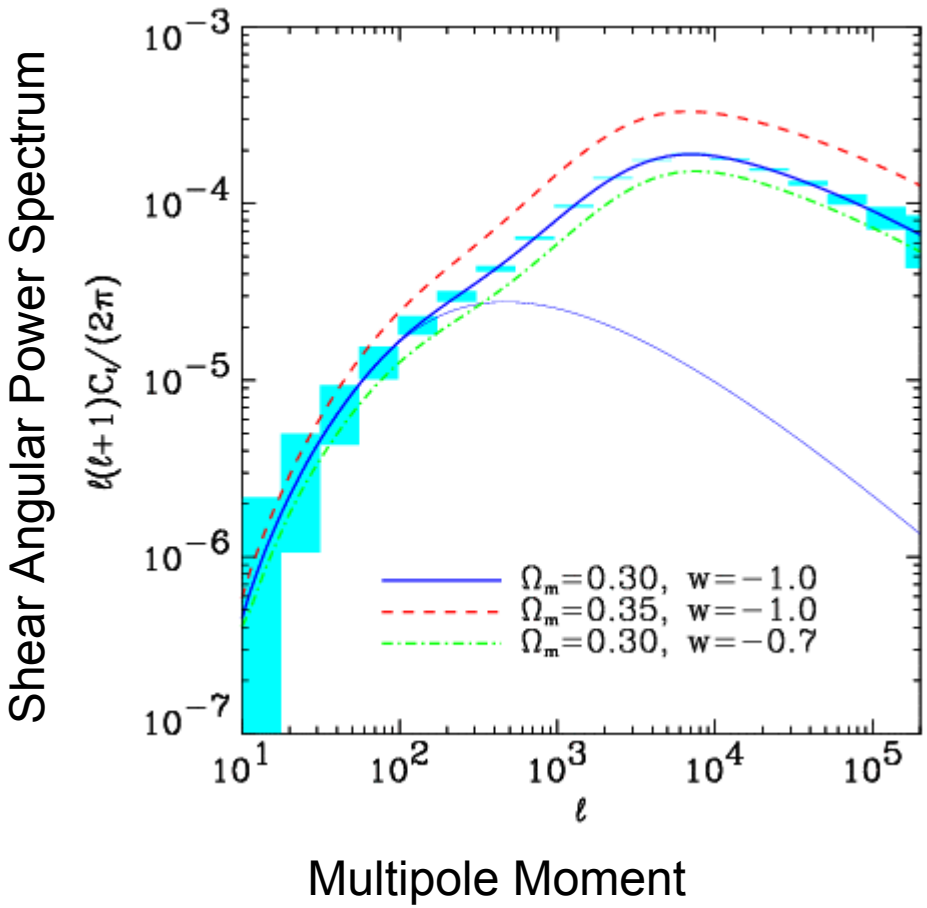
CMB Anisotropies

Type Ia Supernovae Brightness



Tonry et al., 2003

Dark Energy



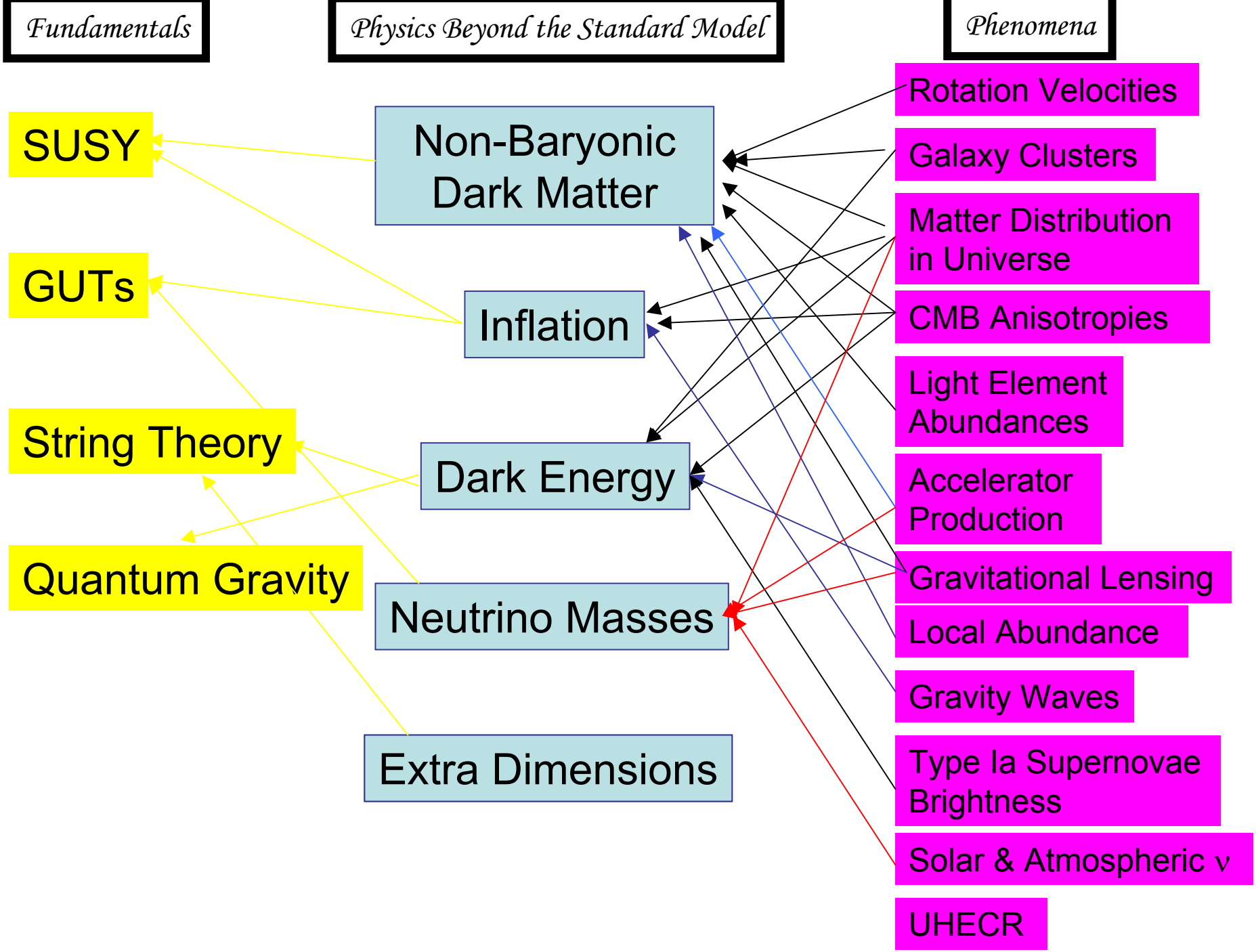
Galaxy Clusters

Matter Distribution in Universe

CMB Anisotropies

Type Ia Supernovae Brightness

Gravitational Lensing


Fundamentals
Physics Beyond the Standard Model
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SUSY
GUTs
String Theory
Quantum Gravity
Non-Baryonic Dark Matter
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Dark Energy
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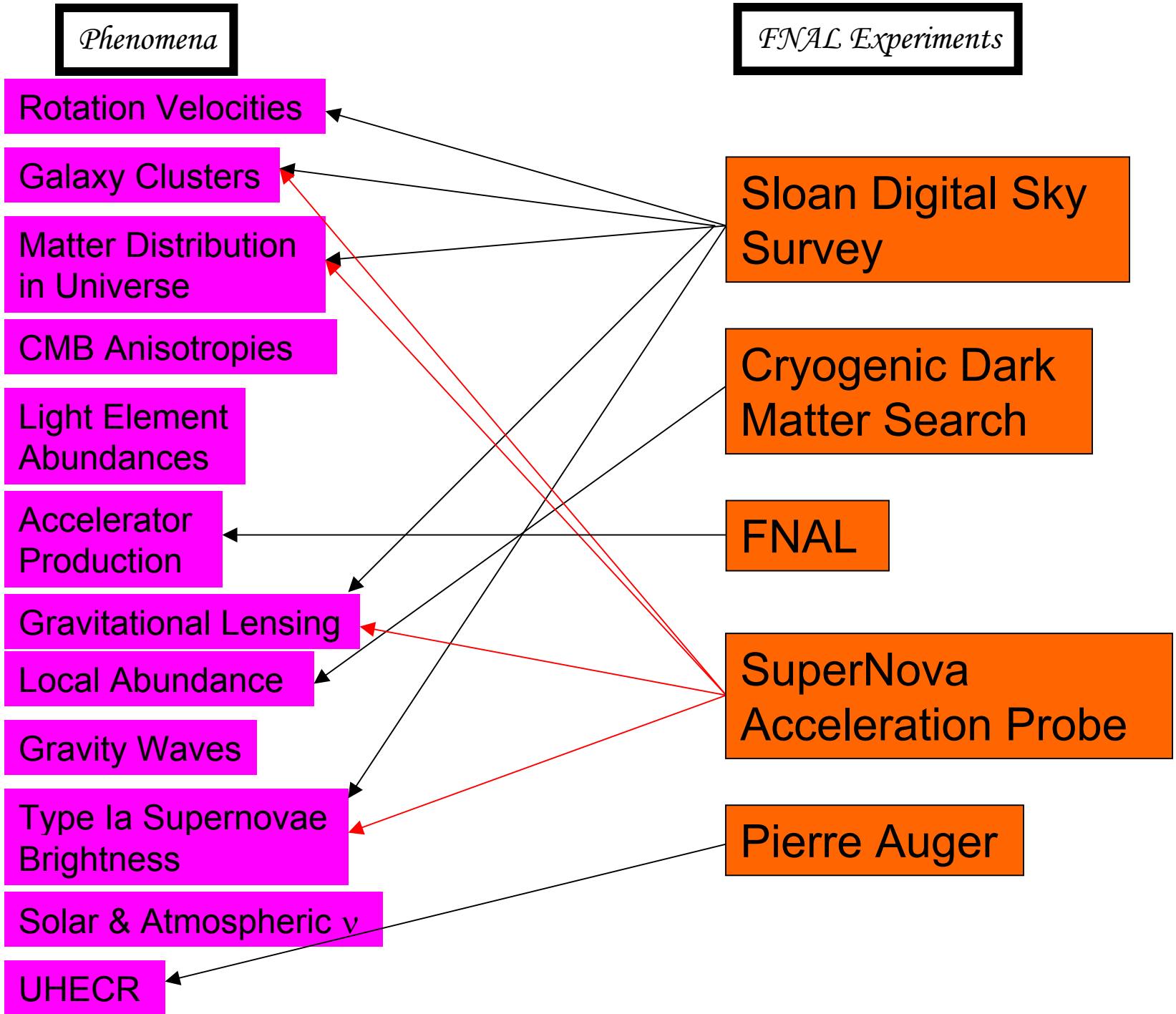
Extra Dimensions
Rotation Velocities
Galaxy Clusters
Matter Distribution in Universe
CMB Anisotropies
Light Element Abundances
Accelerator Production
Gravitational Lensing
Local Abundance
Gravity Waves
Type Ia Supernovae Brightness
Solar & Atmospheric ν
UHECR


Phenomena
FNAL Experiments
Rotation Velocities
Galaxy Clusters
Matter Distribution in Universe
CMB Anisotropies
Light Element Abundances
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Gravitational Lensing
Local Abundance
Gravity Waves
Type Ia Supernovae Brightness
Solar & Atmospheric ν
UHECR
Sloan Digital Sky Survey
Cryogenic Dark Matter Search
FNAL
SuperNova Acceleration Probe
Pierre Auger

Fermilab Astrophysics Center

- Unify FNAL astrophysics program, thereby enhancing the overall intellectual environment and recruiting power of individual projects

- Provide the framework in which future efforts will germinate and be advocated

- Attract scientists from FNAL and User community interested in learning about particle astrophysics

Fermilab Astrophysics Center

- Head reports directly to Lab Director

- Fermilab Astrophysics Center will be *intra*divisional. All astrophysics groups will continue to report to their division heads

- Interim Head: Rocky Kolb