Astroparticle (PC) activities at CERN-TH

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CERN

Members at CERN-TH involved in Astroparticle activities

- 21 Staff scientists (11 IC, 10 LD)
- ~35 Fellows, ~10 PAs, ~10 PhD students
- 8 Staff scientists, 8 fellows, 4PAs and 2 PhD students

} decleare interest in AP

However, in the official hiring process

- 3 Staff scientists (1 IC, 2 LD)
- ~2 Fellows
- 2 Phd students

} AP label

G. Dvali (Staff) :

Degravitation & the acceleration of the Universe

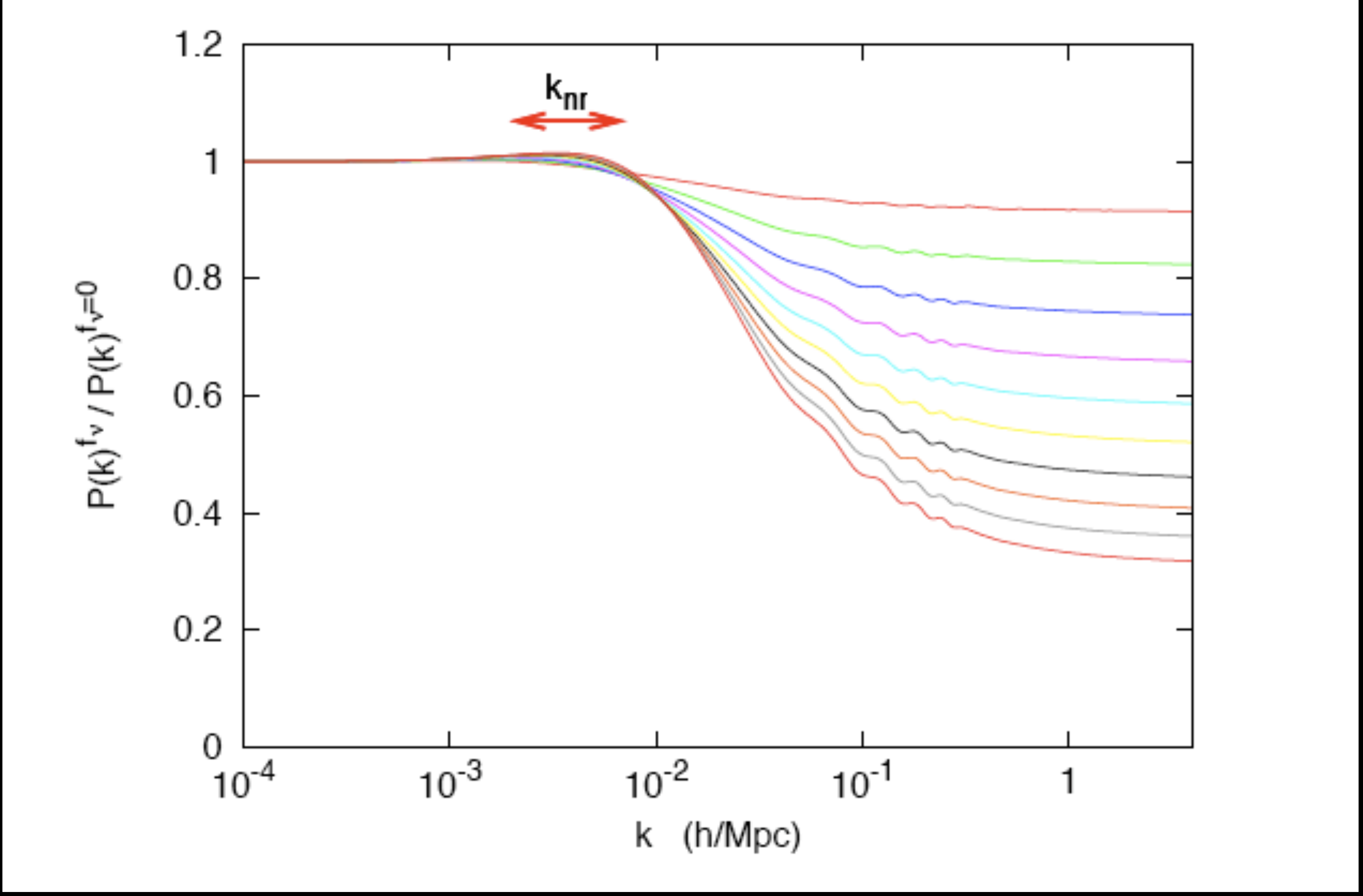
$$G_{\mathrm{N}}^{-1}\left(L^{2}\Box\right)G_{\mu\nu} = 8\,\pi\,T_{\mu\nu}$$

All these class of theories predict the presence of extra longitudinal degrees of freedom of the gravitaton which becomes strongly coupled at distances

$$\begin{aligned} r_{\star} &= \left(L^{4(1-\alpha)}r_{g}\right)^{\frac{1}{1+4(1-\alpha)}}, \\ r_{g} &= 2\,G_{\mathrm{N}}\,M \end{aligned}$$

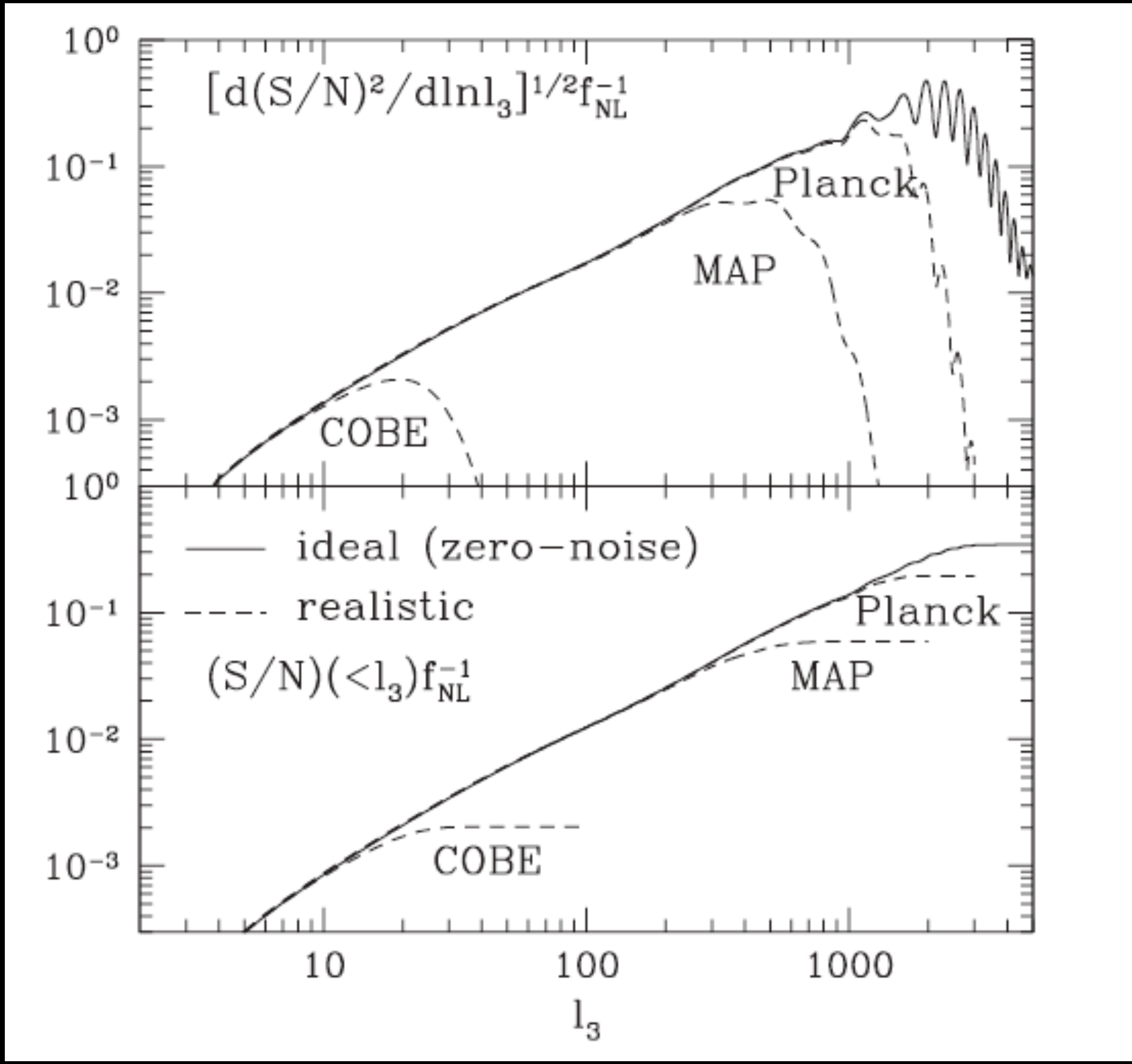
$$\delta \sim \left(\frac{r}{L}\right)^{2(1-\alpha)}\sqrt{\frac{r}{r_{g}}}$$

J. Lesgourgues (CERN+Lausanne, Planck) : massive neutrinos and cosmology



AR (Staff, CMBPol) : CMB & Non-Gaussianity

$$\frac{\Delta T}{T} \simeq \left(\frac{\Delta T_{\rm L}}{T}\right) + f_{\rm NL}\left(\frac{\Delta T_{\rm L}}{T}\right)^2$$



$$\left(\frac{S}{N}\right)_{\rm prim} \sim 10^{-4} f_{\rm NL}\,\ell$$

$$\Delta f_{\rm NL} \sim 20,\ \ell_{\max} \sim 500\ ({\rm WMAP})$$
$$\Delta f_{\rm NL} \sim 3,\ \ell_{\max} \sim 3000\ ({\rm Planck})$$
$$\Delta f_{\rm NL} \sim 2,\ ({\rm ideal\ \ experiment})$$

N. Bartolo, E. Komatsu, S. Matarrese and A.R., Phys. Rept. 402, 103 (2004)

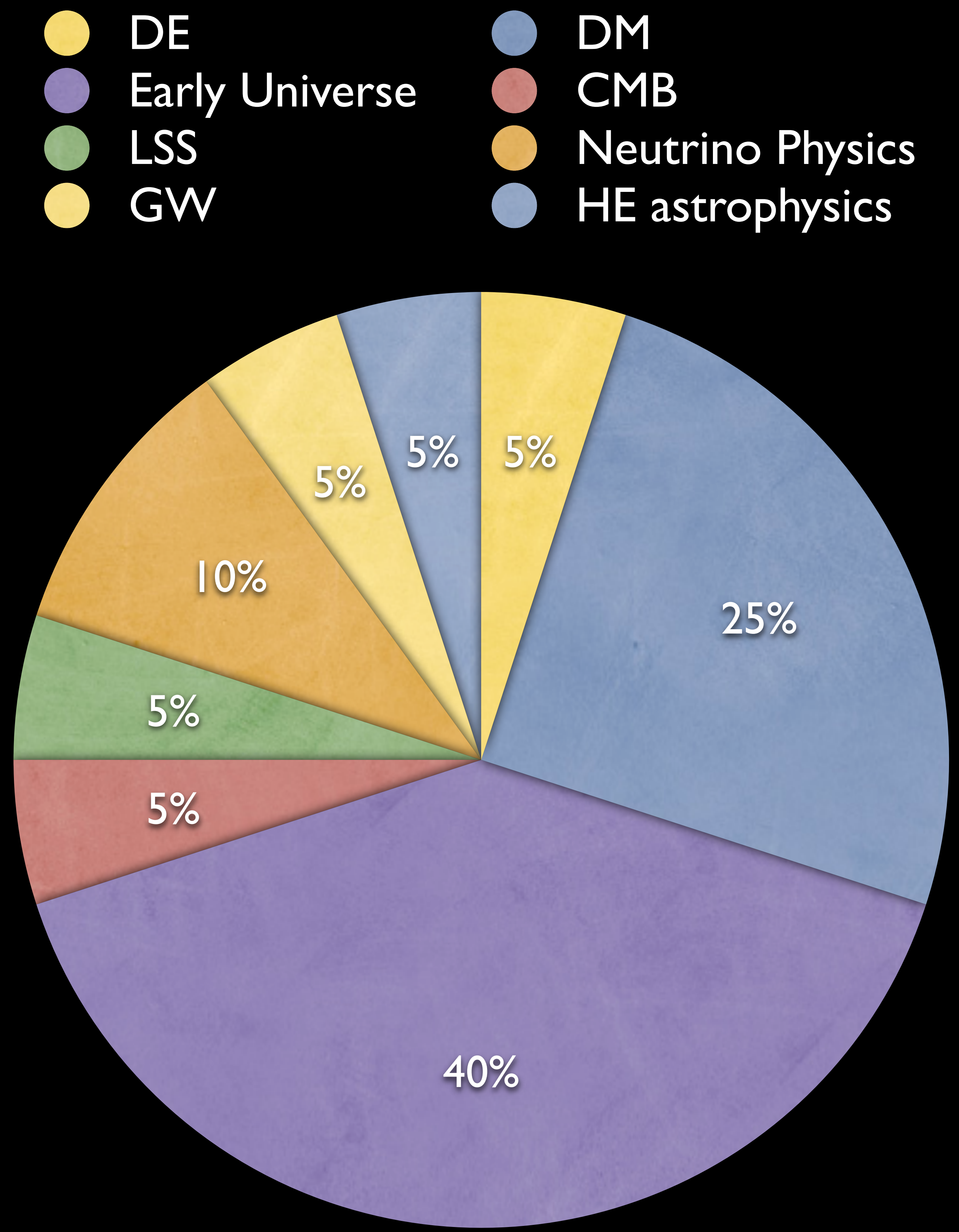
Incomplete list of activities

- DM (abundance, direct detection, astrophysics, LHC), J. Ellis
- Baryogenesis & Leptogenesis
- Neutrino physics (oscillations, cosmology)
- CMB physics (NG)
- Inflation
- GWs (phase transitions)
- Cosmic and gamma rays A. de Rujula
- Modification of gravity at large distances, DE
- Connection to forthcoming experiments (Planck, CMBpol)
- WDM

Current Reserch Lines

- DE
- Early Universe
- LSS
- GW
- DM
- CMB
- Neutrino Physics
- HE astrophysics

Current Reserch Lines



Status and Perspective of Astroparticle Physics in Europe

The basic questions

Recommendations for the evolution of the field over the next decade were formulated by addressing a set of basic questions:

1) What is the Universe made of? In particular: What is dark matter?
2) Do protons have a finite life time?
3) What are the properties of neutrinos? What is their role in cosmic evolution?
4) What do neutrinos tell us about the interior of the Sun and the Earth, and about Supernova explosions?
5) What is the origin of cosmic rays ? What is the view of the sky at extreme energies ?
6) Can we detect gravitational waves ? What will they tell us about violent cosmic processes and about the nature of gravity?

An answer to any of these questions would mark a major break-through in understanding the Universe and would open an entirely new field of research on its own.

SIXTH FRAMEWORK PROGRAMME

ApPEC

ASPERA

Partecipation to networks

- EU FP6 Marie Curie RTN: The quest for unification: Theory confronts experiments (2004-2008), C. Grojean (~20 partecipants)
- EU FP6 Marie Curie RTN: The origin of our Universe (UniverseNet) (2006-2010), J. Ellis (~10 partecipants)
- ILIAS [ENTApP, all WGs (neutrino, DM, GW), Aspera]
- Marie Curie Initial Training Network
- ERC starting grant

More in detail:

project	ref	project dates			ESTs currently at CERN					total no. of ESTs during project lifetime					
		start	end	run so far	f	m	total	% f	% m	f	m	total	% f	% m	months
Eurothephy	MEST-CT-2005-020238	2.1.10	1.1.14	55%	1	7	8	13%	88%	4	18	22	18%	82%	226
Universenet (partner)	MRTN-CT-2006 -035863	2.10.10	1.10.14	36%	1	0	1	100%	0%	1	2	3	33%	67%	12
QUEST (partner)	MCRTN-CT-2004-503369	2.10.08	1.10.12	86%	0	2	2	0%	100%	0	2	2	0%	100%	8
MCNet *	MRTN-CT-2006-035606	2.1.11	1.1.15	30%	0	2	2	0	100%	0	2	2	0	100%	30.07

* the 30.07 months on MCnet include 5 short-term visitors to the network of 1-4 weeks

Conclusions & comments

- CERN-TH interest in astroparticle physics on irregular basis in the past, more coherent recently
- Strong involvement of non-European partners: on small scale already planned at CERN-TH, strictly related to LHC at the moment, possibly extended to other fields (decreases CERN money input, creates ties overseas)
- Strong ties with experimental efforts (Task Force)
- More effort on DE? Strong interest from ESA (observer status), DUNE (2015-2025)?
- AP institutes

REPORT OF THE

DARK ENERGY TASK FORCE

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Gary Bernstein, University of Pennsylvania
Robert Cahn, Lawrence Berkeley National Laboratory
Wendy L. Freedman, Carnegie Observatories
Jacqueline Hewitt, Massachusetts Institute of Technology
Wayne Hu, University of Chicago
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Nicholas B. Suntzeff, Texas A&M University

Dark energy appears to be the dominant component of the physical Universe, yet there is no persuasive theoretical explanation for its existence or magnitude. The acceleration of the Universe is, along with dark matter, the observed phenomenon that most directly demonstrates that our theories of fundamental particles and gravity are either incorrect or incomplete. Most experts believe that nothing short of a revolution in our understanding of fundamental physics will be required to achieve a full understanding of the cosmic acceleration. For these reasons, the nature of dark energy ranks among the very most compelling of all outstanding problems in physical science. These circumstances demand an ambitious observational program to determine the dark energy properties as well as possible.

The Dark Energy Task Force (DETF) was established by the Astronomy and Astrophysics Advisory Committee (AAAC) and the High Energy Physics Advisory Panel (HEPAP) as a joint sub-committee to advise the Department of Energy, the National Aeronautics and Space Administration, and the National Science Foundation on future dark energy research.

Our recommendations are based on the results of our modeling. They are discussed in detail in Section V. In summary, they are

I. We strongly recommend that there be an aggressive program to explore dark energy as fully as possible, since it challenges our understanding of fundamental physical laws and the nature of the cosmos.

II. We recommend that the dark energy program have multiple techniques at every stage, at least one of which is a probe sensitive to the growth of cosmological structure in the form of galaxies and clusters of galaxies.

III. We recommend that the dark energy program include a combination of techniques from one or more Stage III projects designed to achieve, in combination, at least a <u>factor of three</u> gain over Stage II in the DETF figure of merit, based on critical appraisals of likely statistical and systematic uncertainties.

IV. We recommend that the dark energy program include a combination of techniques from one or more Stage IV projects designed to achieve, in combination, at least a <u>factor of ten</u> gain over Stage II in the DETF figure of merit, based on critical appraisals of likely statistical and systematic uncertainties. Because JDEM, LST, and SKA all offer promising avenues to greatly improved understanding of dark energy, we recommend continued research and development investments to optimize the programs and to address remaining technical questions and systematic-error risks.

V. We recommend that high priority for near-term funding should be given as well to projects that will improve our understanding of the dominant systematic effects in dark energy measurements and, wherever possible, reduce them, even if they do not immediately increase the DETF figure of merit.

VI. We recommend that the community and the funding agencies develop a coherent program of experiments designed to meet the goals and criteria set out in these recommendations.