Theory

71. PRC meeting

Hamburg, April 28, 2011

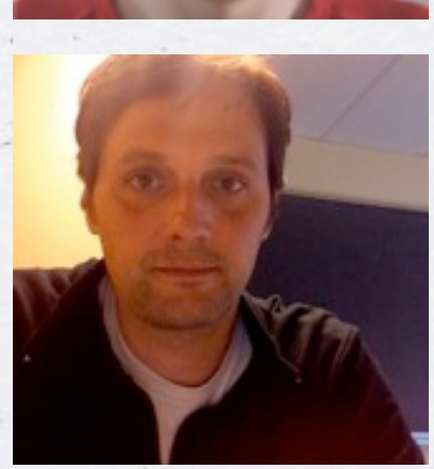
Alexander Westphal, DESY
Particle Cosmology

(1) Theory News – (2) Particle Cosmology
(2a) Structure (2b) Some Science

News

Academic Staff

Academic Staff



* HH: 2 permanent staff positions are filled - Particle Pheno

Juergen Reuter (started Jan 1): Physics beyond the SM, EW symmetry breaking, Monte Carlo event generators, effective field theories

Andreas Weiler (starts July 1): Physics beyond the SM, theory and phenomenology of EW symmetry breaking, collider and flavour physics

* HH: 1 permanent staff position being filled - Particle Cosmo replacement for Laura Covi

* Volker Schomerus, DESY string theory, receives "Gay-Lussac Humboldt Award 2010"

* Ahmed Ali retires in April 2011 (farewell sympos. June 21)

Research Training Group 1670

MATHEMATICS INSPIRED BY STRING THEORY AND QUANTUM FIELD THEORY

Funding

SEVENTH FRAMEWORK PROGRAMME

GIF

HELMHOLTZ ASSOCIATION

MARIE CURIE ACTIONS

New Funding

* NEW Graduiertenkolleg 1670 with DFG funding:
  "Mathematics inspired by string theory and QFT"
  started in spring 2011, see also http://grk1670.math.uni-hamburg.de/
  Joint initiative in the framework of the Center for Mathematical Physics (ZMP).
  Joerg Teschner is deputy Spokesperson

* Helmholtz Alliance funding: Pheno postdoc position (HERWIG), filled by S. Plaetzer since Nov 1, 2010

Workshops

From Sigma Models to Four-dimensional QFT

29 November - 3 December 2010

Home | Scientific Program | Registration | Transparencies | Travel and Accomodation | Contact

QFT2010, Workshop: Nov. 29th - Dec. 3rd, 2010

From Sigma Models to Four-dimensional QFT

Nov. 29th to Dec. 3rd, 2010
DESY Hamburg, Germany

The intentions of the workshop can be described as follows:

In the last few years many striking connections have been discovered between sigma models in low dimensions, conformal field theories, integrable models and four-dimensional supersymmetric gauge theories, in particular

- the study of N=4, d=4 SYM in terms of the AdS_5 sigma-model via the AdS-CFT-correspondence and integrability,
- the discovery of connections between S-duality in four-dimensional gauge theory and the geometric Langlands correspondence via 2d sigma models with Hitchin moduli spaces as targets,
- the relations between gauge theory and the quantization of algebraically integrable models like Toda, Calogero and Hitchin systems,
- the discovery that Liouville theory allows one to calculate partition functions and expectation values of loop operators in SUSY gauge theory on S^4,
- the relations between the thermodynamic Bethe ansatz equations, wallcrossing and scattering amplitudes in N=4 SYM.

It seems to us that the potential of these discoveries is far from being exploited, and that understanding their origin and their mutual relations will lead to deep insights into the physics and mathematics of gauge theories. We therefore plan to bring together researchers from different branches of physics and mathematics in order to stimulate further progress in these fields of research.

Speakers:
S. Alexandrov, G. Arutyunov, J. Bartels, V. Bazhanov, N. Beisert, N. Drukker, S. Frolov, S. Gukov, R. Janik, V. Kazakov, A. Klemm, C. Kozcaz, S. Lee, L. Lipatov, A. Litvinov, J. Maldacena, A. Marshakov, N. Nekrasov, V. Pestun, B. Pozsgai, A. Sever, S. Shatashvili, M. Staudacher, M. Taki, S. Vandoren, P. Vieira, K. Zarembo

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String Steilkurs - Part I

"*Introduction to String Theory*"

21.03 - 25.03.2011

QuickLinks
DESY Theory Group
DESY

University of Hamburg & DESY

The course offers three series of lectures on String Theory, Supersymmetry and Conformal Field Theory. Knowledge in Quantum Field Theory and General Relativity is assumed.

Lecturers:

- Rutger Boels: "Supersymmetry and Supergravity"
- Volker Schomerus: "Introduction to String Theory"
- Jörg Teschner: "Conformal Field Theory"

Jan Louis
II. Institute for Theoretical Physics
University of Hamburg
Luruper Chaussee 149
22761 Hamburg

There is no fee for the course but we cannot reimburse expenses of participants.
Deadline for registration is March 1, 2011!

The String Steilkurs is an activity within the SFB 676 collaboration.

Last modified: Tue Dec 14 20:03:02 CEST 2010

HELMHOLTZ GEMEINSCHAFT

DESY THEORY WORKSHOP
SEPT. 27 - 30, 2011
DESY, Hamburg, Germany

COSMOLOGY MEETS PARTICLE PHYSICS
IDEAS & MEASUREMENTS

PLENARY SESSIONS — **Sept. 27 - 30, 2011**

R. B[illegible] (Paris)
H. C[illegible] (Beirut)
[illegible] (DESY)
Danzmann (Hannover)
P. Di Bari (Southampton)
S. Dubovsky (New York)
J. Dunkley (Oxford/Princeton)
G. Dvali (Munich)
B. Garbrecht (Aachen)
D.E. Kharzeev (Brookhaven)
T. Konstandin (CERN)
A. Lindner (DESY)
L. McAllister (Cornell)
P. Schleper(Hamburg)
B. Schutz (Golm)
M. Shaposhnikov (Lausanne)
A.A. Starobinsky (Moscow)
C. Weinheimer (Münster)
P. Wells (CERN)
S. Zaroubi (Groningen)

DESY Heinrich-Hertz Lecture on Physics
T.T. Yanagida (IPMU Tokyo)

PARALLEL SESSIONS AND CONVENORS — **Sept. 28 - 29, 2011**

Contributions by young researchers are especially encouraged. Abstracts can be submitted to the convenors before August 31, 2011. Limited financial support for young physicists is available.

Particle Phenomenology: M. Krämer (Aachen) , T. Mannel (Siegen)

Cosmology & Astroparticle Physics: L. Covi (Göttingen), D. Schwarz (Bielefeld)

Strings & Mathematical Physics: T. Weigand (Heidelberg), M. Zagermann (Hannover)

ORGANIZING COMMITTEE

J. Berges
W. Buchmüller
L. Covi
H. Dreiner
A. Hebecker
V. Mukhanov (chair)
O. Philipsen
A. Ringwald
D. Schwarz
G. Sigl
Y.Y.Y. Wong

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INFORMATION

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workshops hosted & organized

- Workshop “From Sigma Models to Four-dimensional QFT” Nov. 29th – Dec. 3rd, 2010, DESY Hamburg [joint with ZMP]

- Workshop “Foundational Aspects of Cosmology”, Feb 16 - 18, 2011, Hamburg University & DESY Hamburg

- DESY T (HH & Zeuthen) theory meeting, Feb 28, 2011, DESY Hamburg

- School “String Steilkurs - Teil I”, Mar 21 - Mar 25, 2011, DESY Hamburg

- “Workshop on indirect Dark Matter Searches”, June 14-17, 2011, DESY Hamburg

- DESY theory workshop 2011: “Cosmology meets Particle Physics”, Sep 27-30, 2011, DESY Hamburg

further news

* New “Pauli Center Blackboard Seminar” since April 2011 joint with all Hamburg Theory groups. 4 seminars/term. organized by *Robin Santra* and *Volker Schomerus*

* further strengthening of collaboration between Pheno, Analysis Center and Experiments (e.g. postdoc S. Plaetzer)

* monthly “LHC Physics Discussions” with high participation

* workshop seminar “Particles, Strings & the Early Universe”

Theory Group Structure

HEP Exp
HERA,LHC..

UNI HH/B/P

Computing

Collider Pheno

Lattice Theory

NIC

astroparticle

QFT | QCD

Math

Particle Cosmo

String Theory

string pheno

SFB TR 9

SFB 676

ZMP

particle cosmology ...

Members: W. Buchmüller, O. Lebedev, A. Ringwald, A. Westphal, N.N.;
collaboration LEXI-YIG: B. Herrmann
3(DESY)+6(YIG, SFB, LEXI, AvH) PostDocs, 9 PhD students

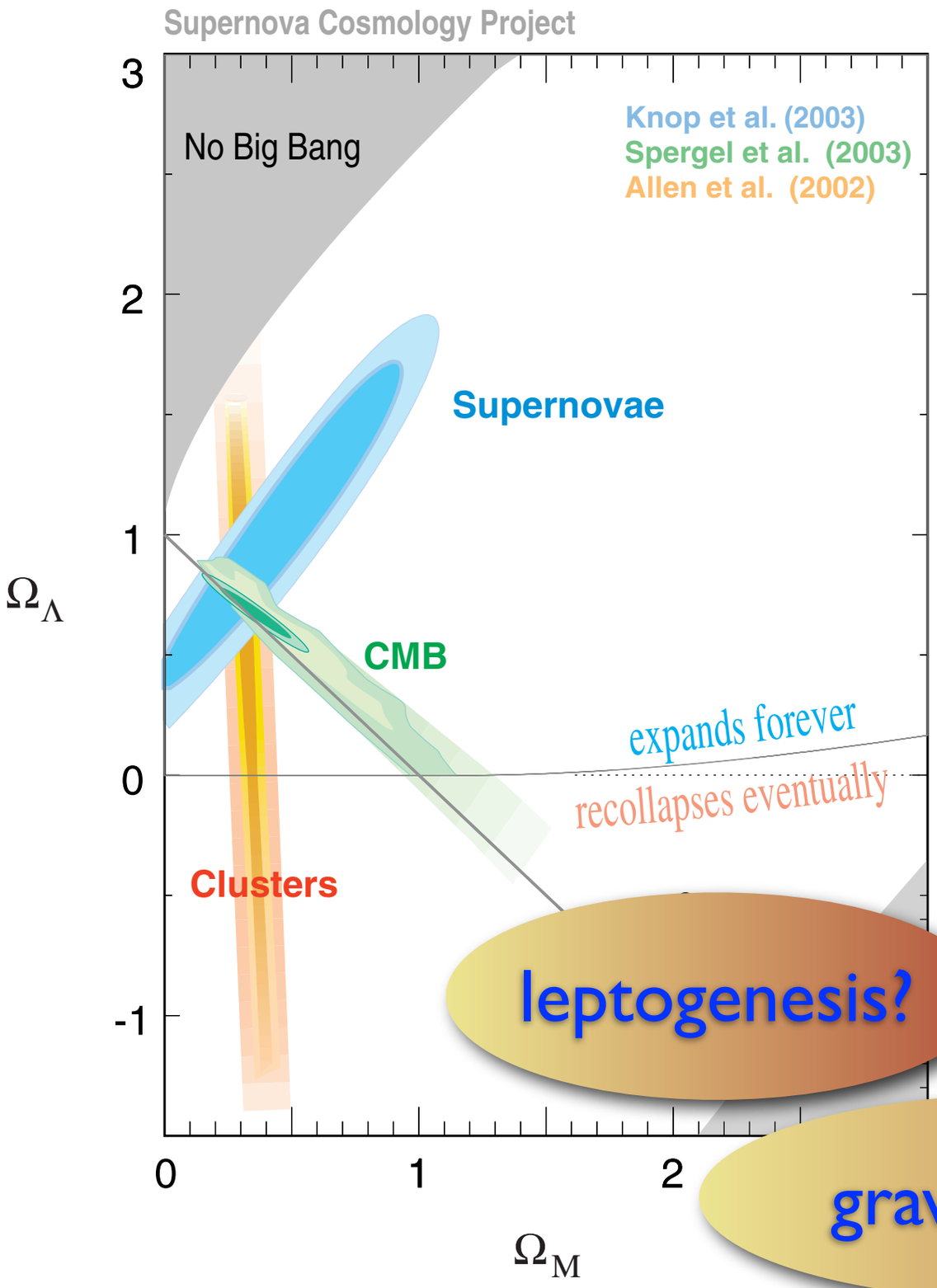
* **Dark Matter:** neutralino annihilation, decaying DM & Fermi-LAT, decaying DM @ LHC (coll.: G. Sigl, Uni HH)

* **baryo-/leptogenesis:** full quantum theory, connection to DM, pre-/reheating, non-equilibrium FT (coll.: K. Fredenhagen, Uni HH)

* **inflation:** inflation in supergravity & string theory, gravity waves, non-gaussianities (coll.: J. Louis, Uni HH)

* **axion-like particles:** hidden U(1)s & flux compactifications, hidden CMB (coll.: G. Sigl, Uni HH)

... in search of a theory !



The "concordance" cosmological model emerged in the last years leaves many question unanswered:

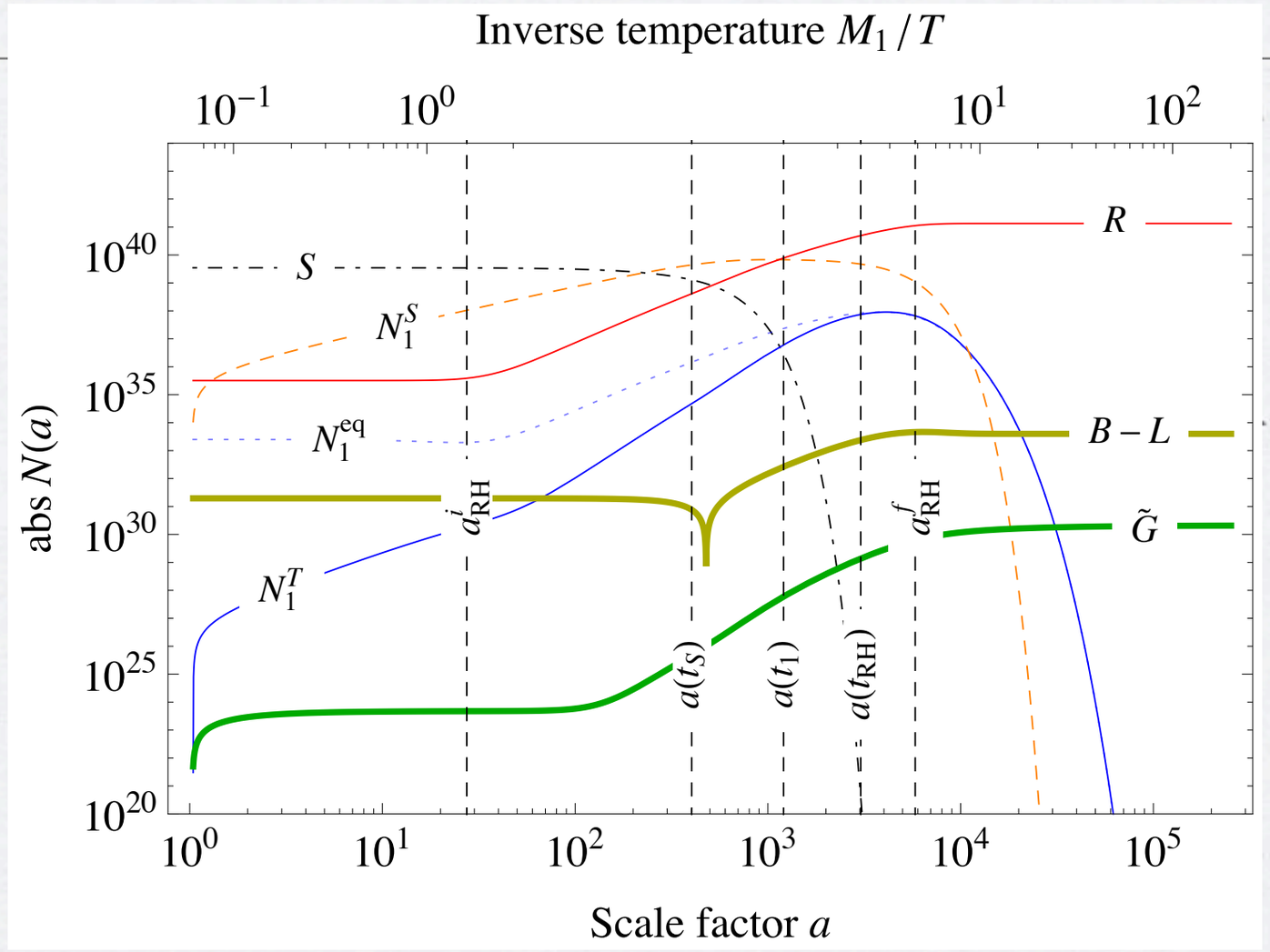
What is Dark Energy ?
What is Dark Matter ?
How do Baryons survive ?
Who is the inflaton ?
How high was T ?
..

leptogenesis?

gravitino LSP?

preheating & gravity waves?

examples



* tachyonic preheating with a $U(1)_{\rm B\text{-}L}$ breaking waterfall field in hybrid inflation can lead to successful leptogenesis and gravitino LSP dark matter – lower bound on $m_{3/2}$ in terms of m_ν
  [Buchmuller, Schmitz & Vertongen '10 / '11]

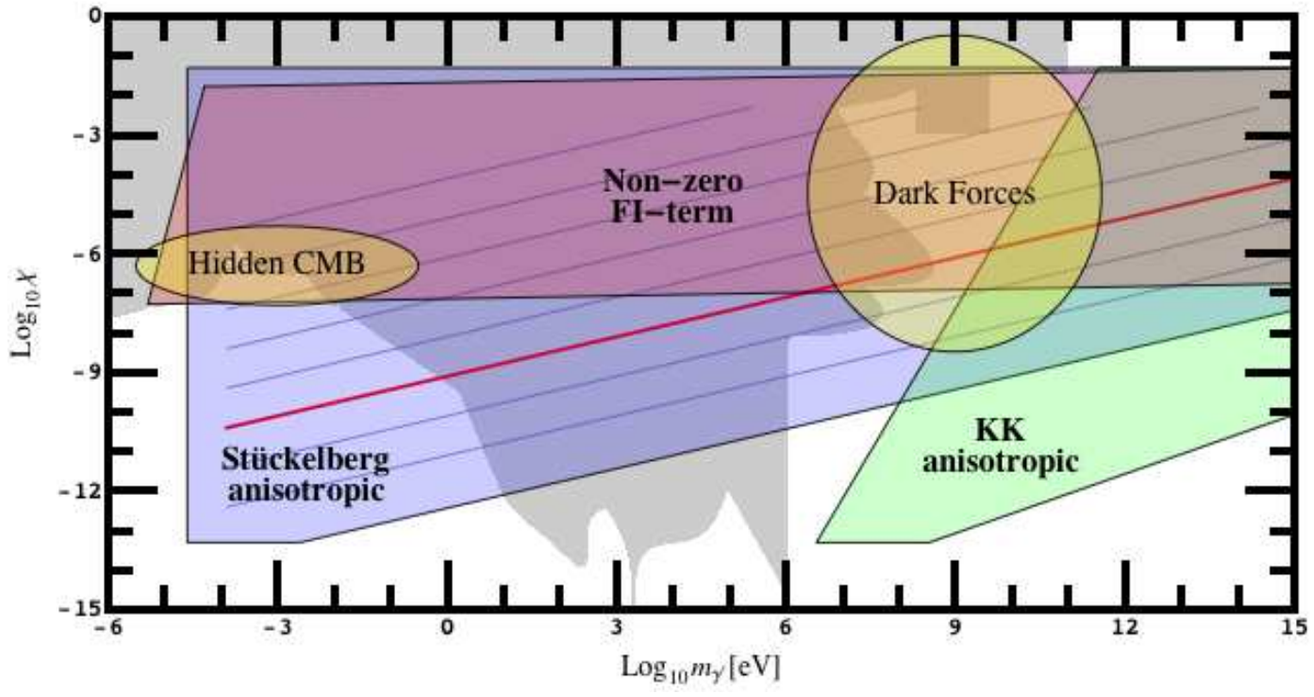
* first bona fide quantum mechanical description of leptogenesis
  [Anisimov, Buchmuller, Drewes & Mendizabal '10]

the Dark Side acts with Dark Forces ...

[Arias, Cicoli, Goodsell, Jaeckel, Redondo, Ringwald]

News on Weakly Interacting Slim Particles (WISPs):

- Type IIB flux compactifications in string phenomenology lead naturally to a GeV-scale hidden photon ("dark forces" that can be searched for in fixed target experiments) for an intermediate string scale; or even to an meV-scale hidden photon (which could lead to a "hidden CMB" and can be tested in the next generation of LSW experiments) in the case of TeV-scale strings, since $m_{\gamma'} \sim M_s^2/M_P$
  - M. Cicoli, M. Goodsell, J. Jaeckel and A. Ringwald, "Testing String Vacua in the Lab: From a Hidden CMB to Dark Forces in Flux Compactifications," arXiv:1103.3705 [hep-th].

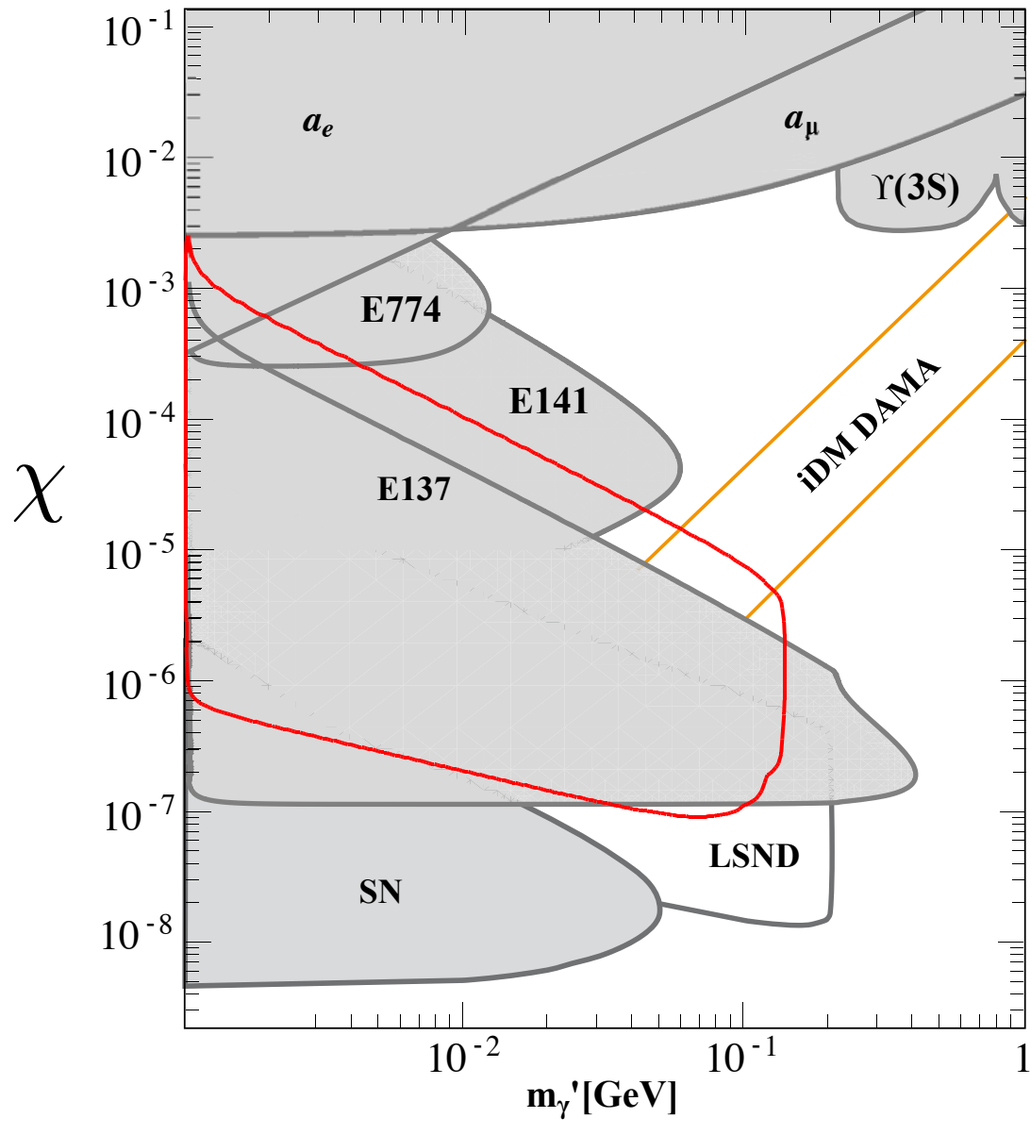


$$\mathcal{L} = \mathcal{L}_{\rm SM} - \frac{1}{4} X_{\mu\nu} X^{\mu\nu} + \frac{\chi}{2} X_{\mu\nu} F^{\mu\nu} + e_\psi \chi \cdot \bar{\psi} \gamma_\mu \psi X^\mu + \frac{m_{\gamma'}^2}{2} X_\mu X^\mu$$

Particle Cosmo news (Zeuthen) - inspired by talk by A. Ringwald at the DESY -T- meeting Feb 2011

J. Blümlein, J. Brunner, DESY 11-062:

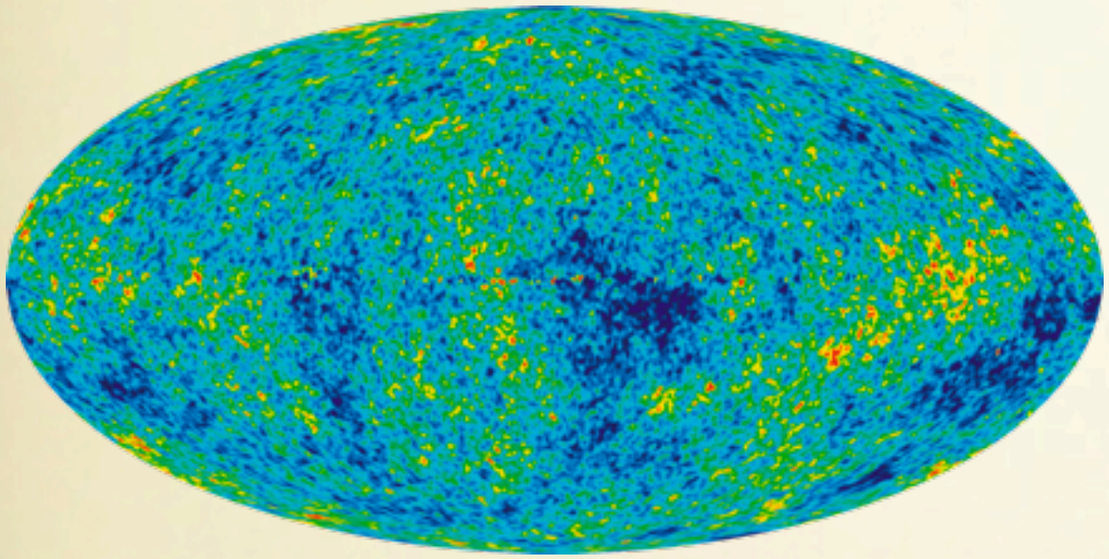
New Exclusion Limits for Dark Gauge Forces from Beam-Dump Data

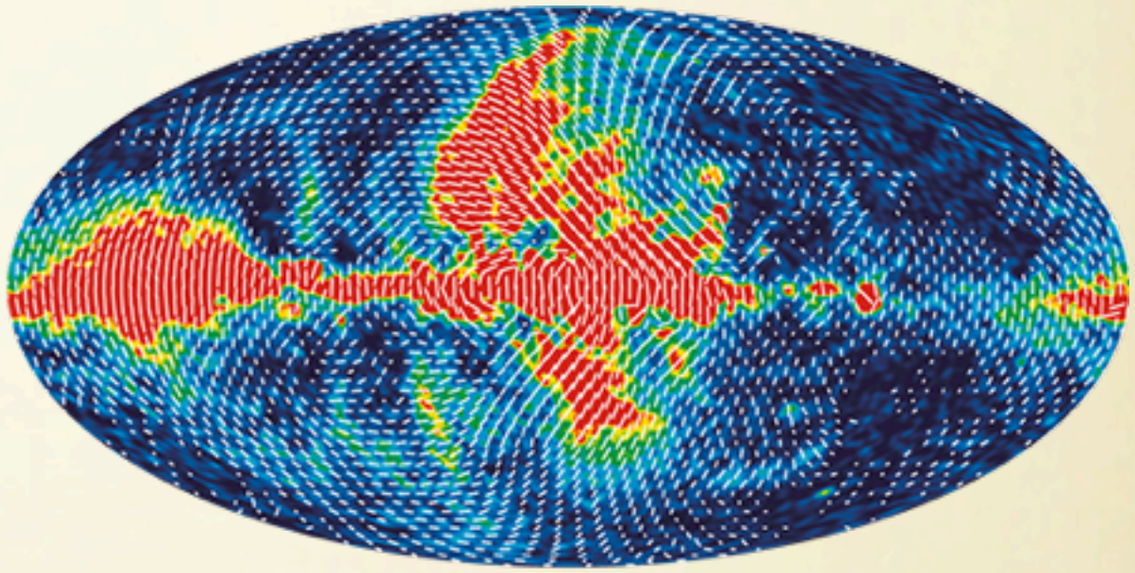


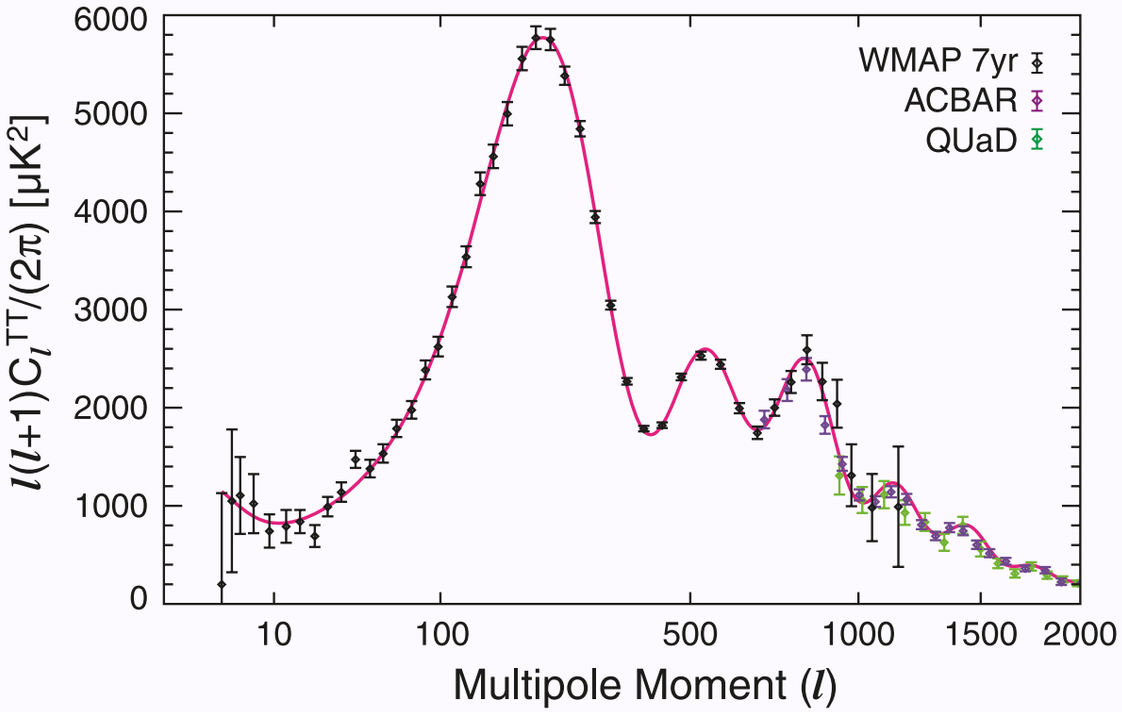
Science News

String Cosmology

an age of precision cosmology ...



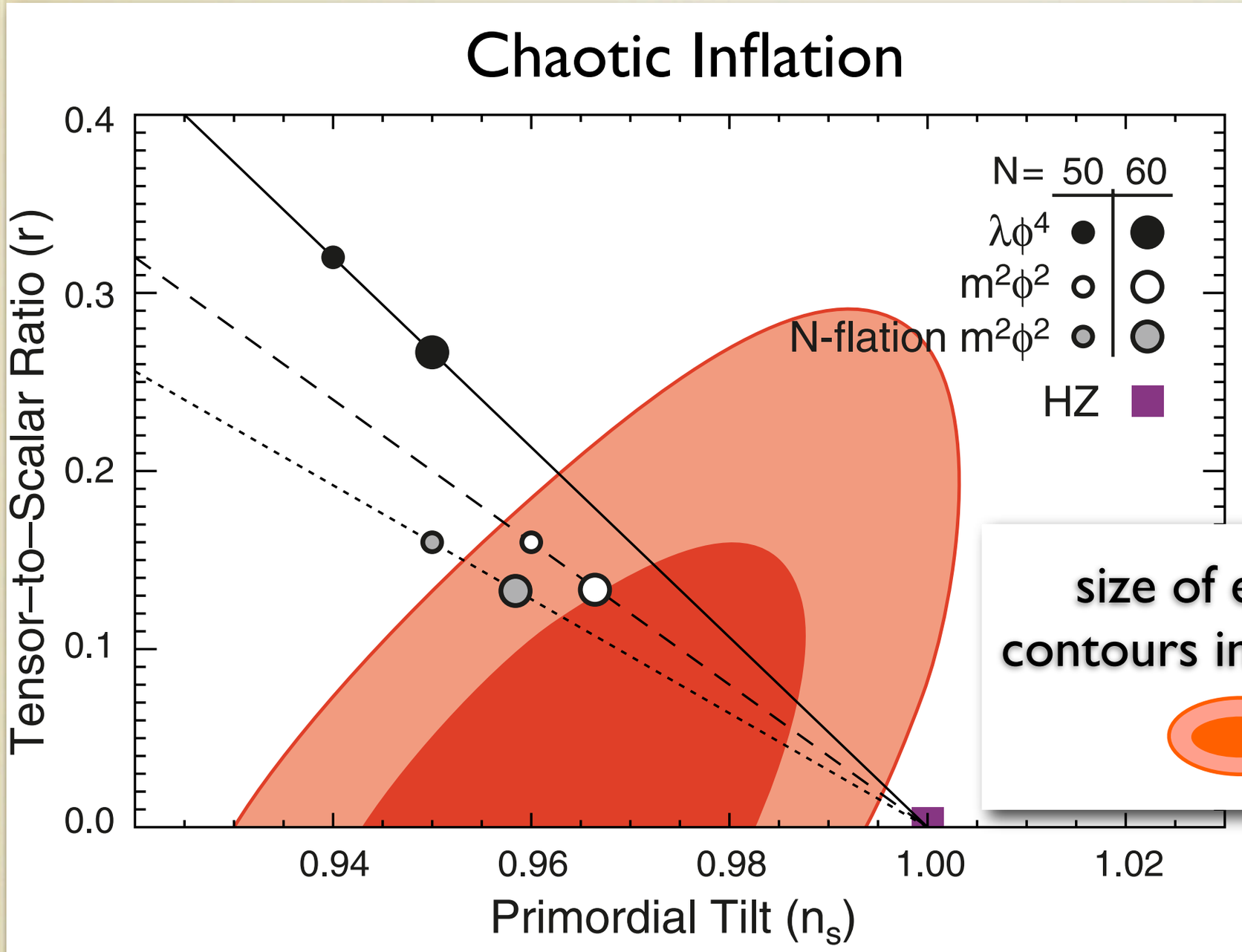




[NASA/WMAP Science Team]

We live in the Golden Age of cosmology !

present status: WMAP 7yr + BAO + H_0



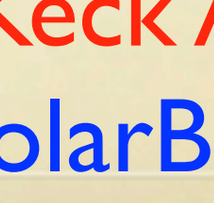
$n_s = 0.963 \pm 0.012$ (68%)

$r < 0.24$ (95%)

$-10 < f_{NL}^{local} < 74$

$-214 < f_{NL}^{equil} < 266$

size of error contours in ~ 5 yrs



expect dramatic improvement in next 5 yrs:

Planck & **BICEP2** taking data, Keck Array ('10...)

SPIDER, Clover, QUIET-II, EBEX, PolarBEAR ...

- the mission:

  ➡ probe *GUT-scale* physics using the CMB and LSS

- the tools:

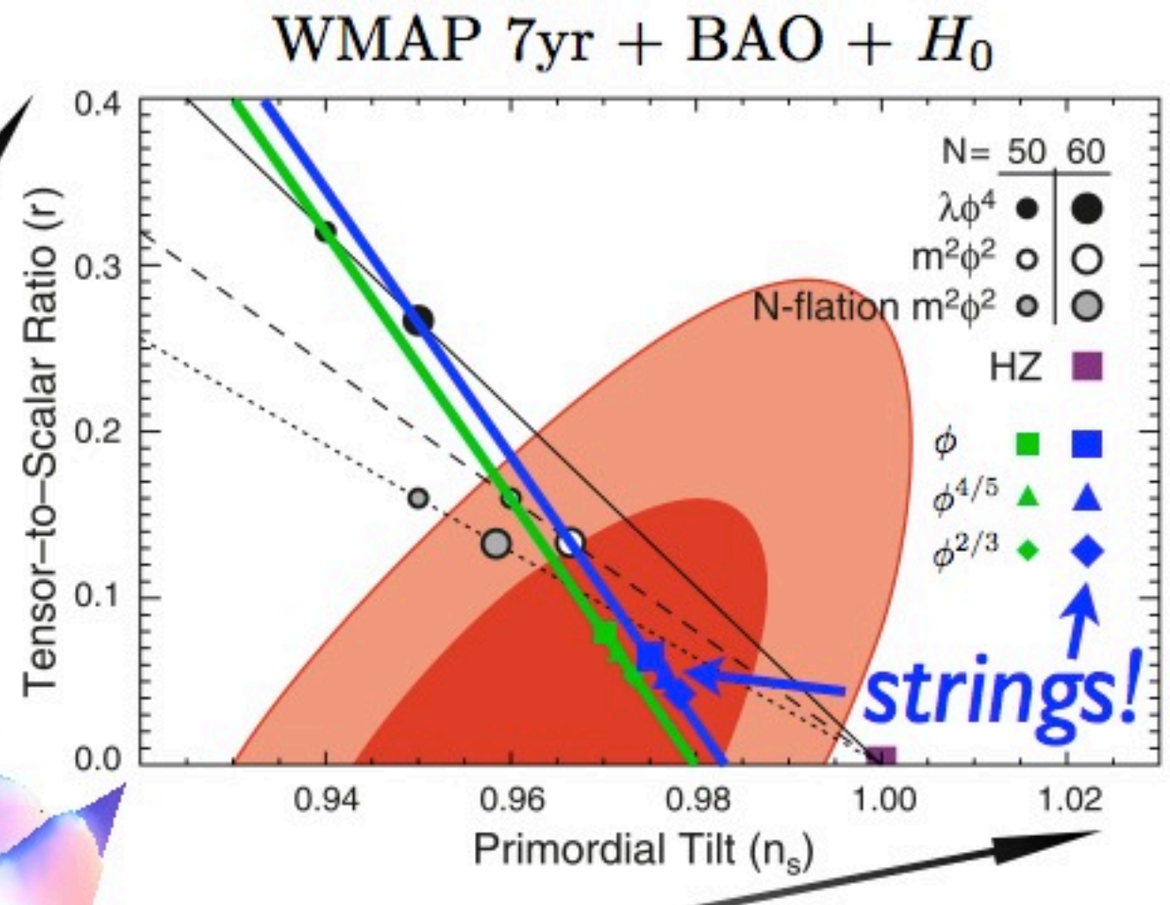
  ➡ use combination of theory & observation to construct & constrain mechanisms of inflation in string theory

  ➡ aim at correlated observables (tilt, tensors, non-gaussianity, isocurvature, ...)

- concrete problem:

  ➡ effective 4d inflaton action from consistent, controlled string compactifications with moduli stabilization

cosmological data:
spectral tilt of density fluctuations (n_S) vs
relative power of primordial gravity waves (r)

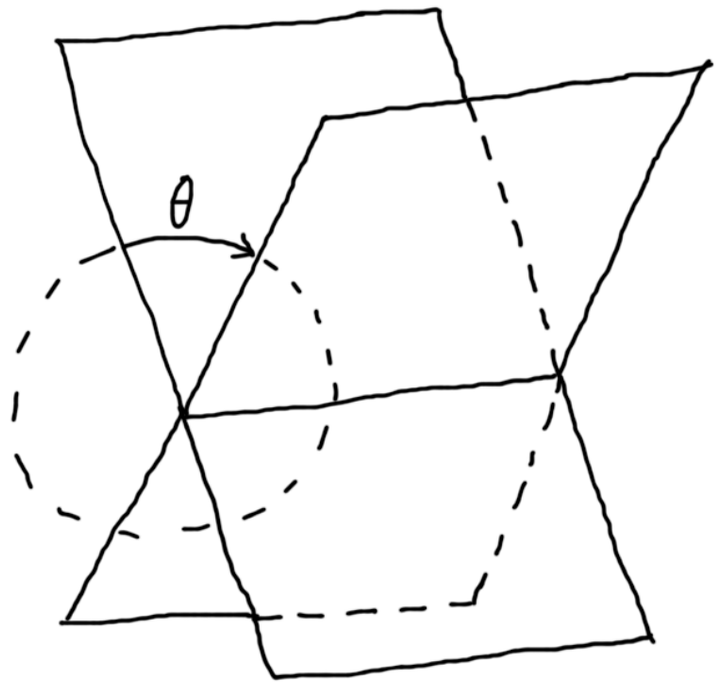


the string theory *landscape*:
MANY (>10^{500}) isolated *vacua*,
scalars get mass from moduli stabilization,
can argue *anthropically* for small CC,
some mountain slopes drive *inflation*

string theory's 6 compact dimensions:
strings , branes & fluxes
shape & size of internal dim.s – "moduli" massless scalar fields

large field inflation in string theory ...

- many good inflaton candidates are periodic, e.g. angles θ_a between branes



- T-duality:

strings on circle of radius R $\longleftrightarrow$ strings on dual circle of radius $\frac{1}{R}$

branes with angle θ $\longleftrightarrow$ branes with 2-form B_2 $\Rightarrow$ axion $b = \int B_2$

- field range is limited (periodicity) to < M_P

[Banks, Dine, Fox & Gorbatov; Srvcek & Witten]

$$\Rightarrow \quad r \equiv \frac{\mathcal{P}_T}{\mathcal{P}_S} = 16\epsilon \leq 0.003 \left(\frac{50}{N_e}\right)^2 \left(\frac{\Delta\phi}{M_{\rm P}}\right)^2 < 0.01$$

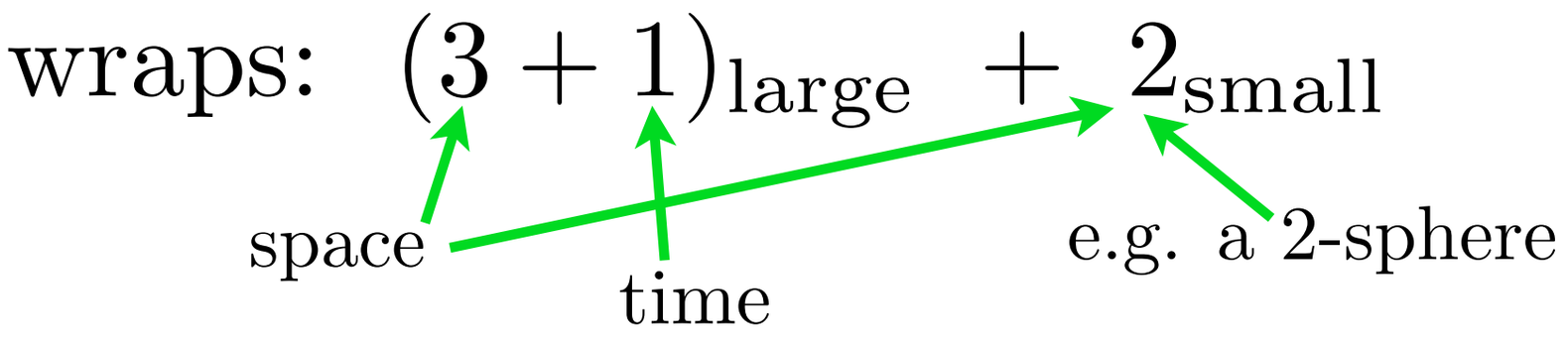
unobservable

[Lyth '97]

a way beyond - axion monodromy inflation

[McAllister, Silverstein & AW '08]

- an example – take a 5-brane:



- put a B_2 (or C_2) field on small 2-sphere with volume v :

$$S_{5-\text{brane}} \sim \frac{1}{g_s} \int_{\mathcal{M}_4 \times \text{2-sphere}} d^6\xi \sqrt{\det(G+B)}$$

$$= \frac{1}{g_s} \int_{\mathcal{M}_4} d^4x \sqrt{-g} \sqrt{v^2 + b^2}$$

non-periodic in ***b*** , has a "monodromy" in ***b***

$$\Rightarrow \; V(b) \sim b \; , \quad b \text{ large, } \textit{non}\text{-periodic}$$

$$n_S \simeq 0.975$$

$$r \simeq 0.08$$

future …

* large-field string inflation – generic "flattening" compared to field theory (flatter than $m^2\phi^2$) – always true??
  [Dong, Horn, Silverstein & AW '10]

* population dynamics & model frequencies: maybe we can predict r statistically, like the CC? testable in CMB … many open questions: tunneling, initial conditions, model space – already begun [Dutta, Vaudrevange & AW '11]

* knowing r gives us an upper limit on T … relevant for: reheating / preheating, baryogenesis/leptogenesis, nature of LSP in SUSY models (gravitino LSP? bino LSP?), …

Future of Particle Cosmology

* **Now a competitive field!**

* **exciting period due to new data:**
  – LHC
  – satellite experiments
  – in-/direct dark matter searches

* **development of theory:**
  – QFT in curved spacetime
  – non-equilibrium field theory
  – connection to string theory

* **crucial for success of DESY theory:**
  – *connection to experiment & observation*, new theoretical developments
  – *close collaboration with Hamburg U.* in all areas

backup material

NNLO Predictions for $W^{\pm}$, Z^0 production cross sections at LHC

S. Alekhin, J. Blümlein, P. Jimenez-Delgado, S. Moch, E. Reya, Phys. Lett. B697 (2011) 127

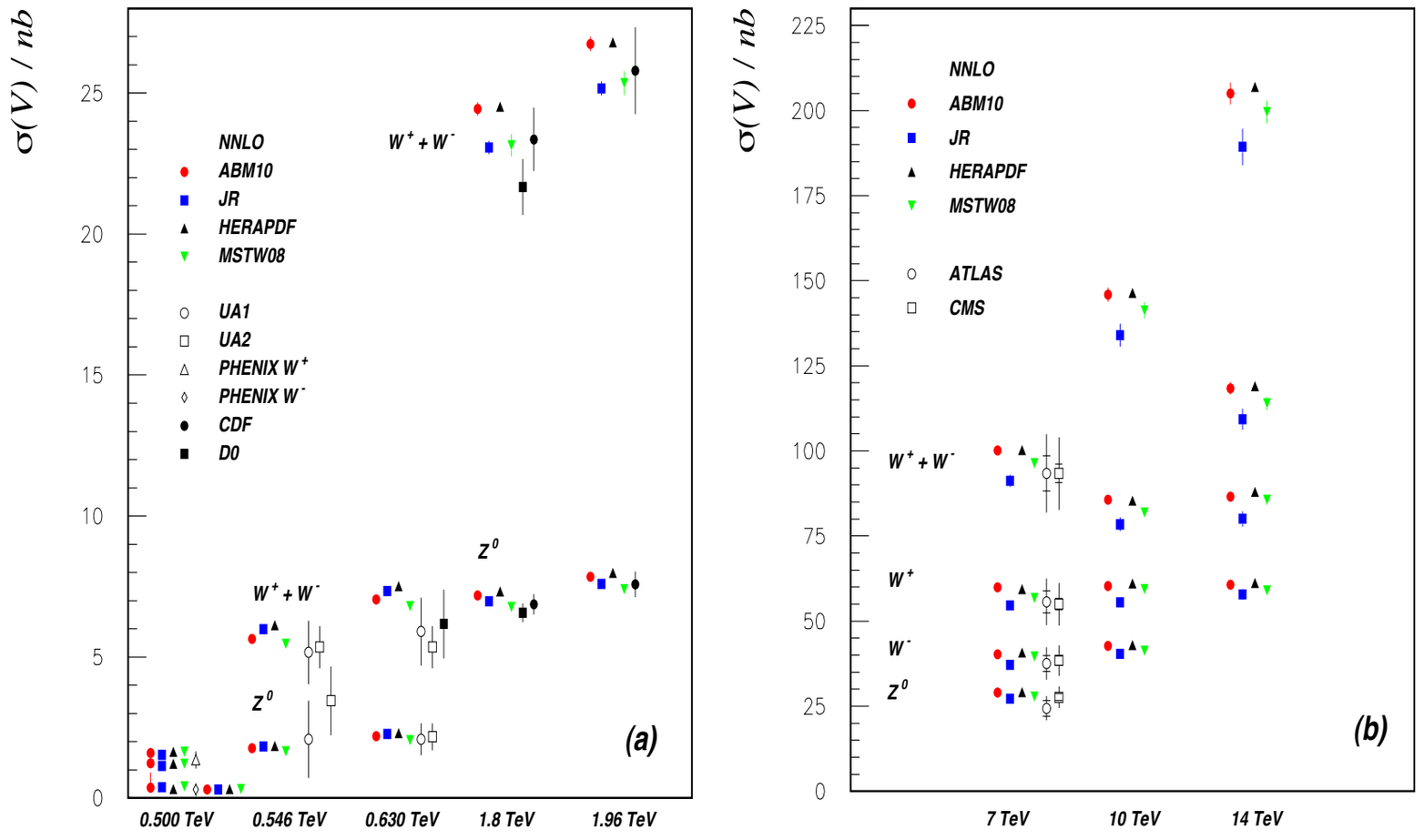
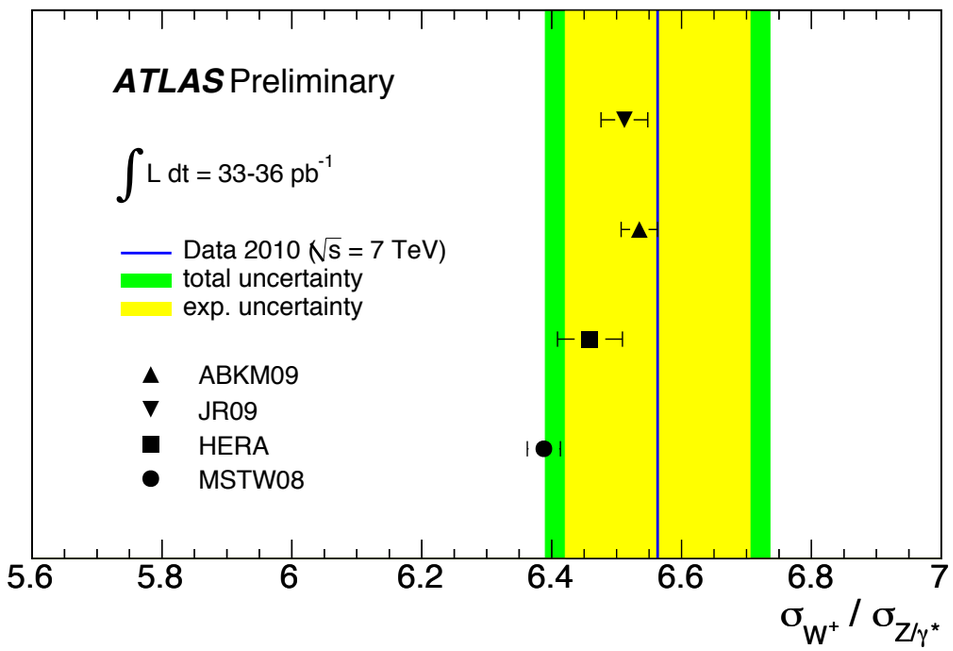


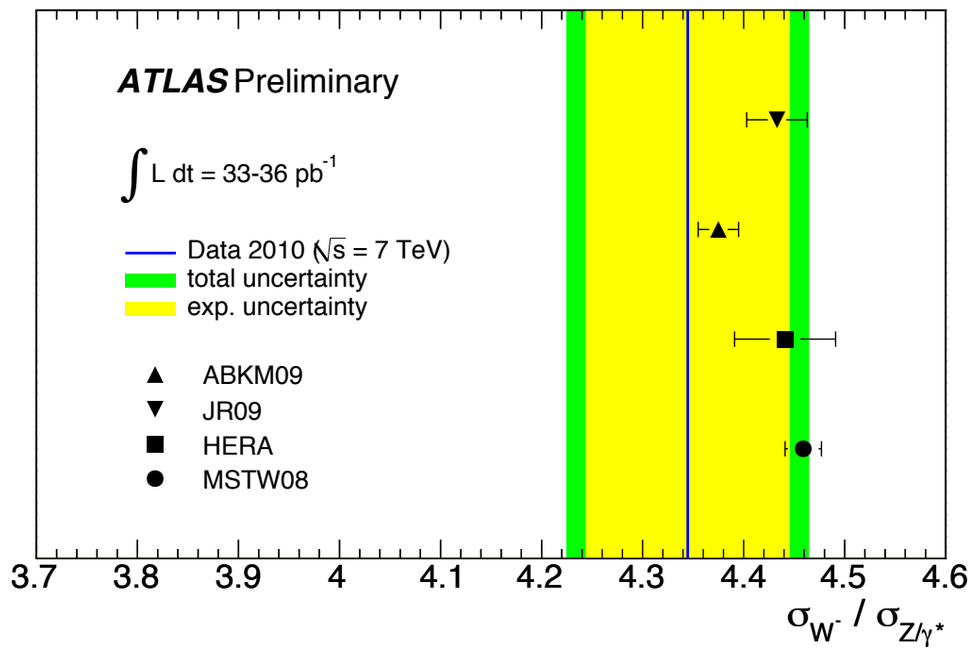
Figure 1: Comparison of different NNLO predictions for the inclusive W^+, W^-, $W^{\pm}$, and Z^0 boson production cross sections in $p\overline{p}$ annihilation and pp scattering ($\sqrt{S} = 0.5$ TeV) based on the pdfs of recent NNLO analyses, ABM,ABKM,JR,HERAPDF,MSTW08,MSTW10, and the corresponding experimental data by UA1,UA2,PHENIX,CDF,CDF1,D0,ATLAS,CMS. Left panel (a): the lower energy region corresponds to $p\overline{p}$ collisions, except at 0.5 TeV, which refers to pp scattering. For the latter case the predictions refer to (from above) $W^+ + W^-, W^+, W^-$ and the ones for Z^0 are given to the right of the ones for W^-. Right panel (b): LHC energies (pp collisions); the inner error bars refer to $(\sigma^2_{\rm stat} + \sigma^2_{\rm syst})^{1/2}$ and the total error is obtained by adding the luminosity error in quadrature.

$W^{\pm}$ and Z^0 production cross sections

Recent measurements of $W^{\pm}$ and Z-production cross sections
at ATLAS ($\sim$ 3% lumi err.)
ATLAS-CONF-2011-041

ABKM predictions: closest to the center line





shades of difficulty ...

- observable tensors link levels of difficulty:

$$r \equiv \frac{\mathcal{P}_T}{\mathcal{P}_S} = 16\epsilon \leq 0.003 \left(\frac{50}{N_e}\right)^2 \left(\frac{\Delta\phi}{M_{\rm P}}\right)^2$$ [Lyth '97]

- $r << O(1/N_e^2)$ models:

$\Delta\phi \ll \mathcal{O}(M_P) \quad \Rightarrow$

Small-Field inflation ... needs control of leading dim-6 operators

➥ enumeration & fine-tuning reasonable

- $r = O(1/N_e^2)$ models:

$\Delta\phi \sim \mathcal{O}(M_P) \quad \Rightarrow$

needs *severe* fine-tuning of all dim-6 operators, or accidental cancellations

- $r = O(1/N_e)$ models:

$\Delta\phi \sim \sqrt{N_e} M_P \gg M_P \quad \Rightarrow$

Large-Field inflation ... needs suppression of all-order corrections

➥ symmetry is essential!

an idea ... [Silverstein & AW '08]

- we need a potential $V(\phi)$ which is monotonic:

$$V(\phi) \to V(\phi + \Delta\phi) > V(\phi) \quad \text{even if:} \quad \phi \to \phi + \Delta\phi = \phi$$

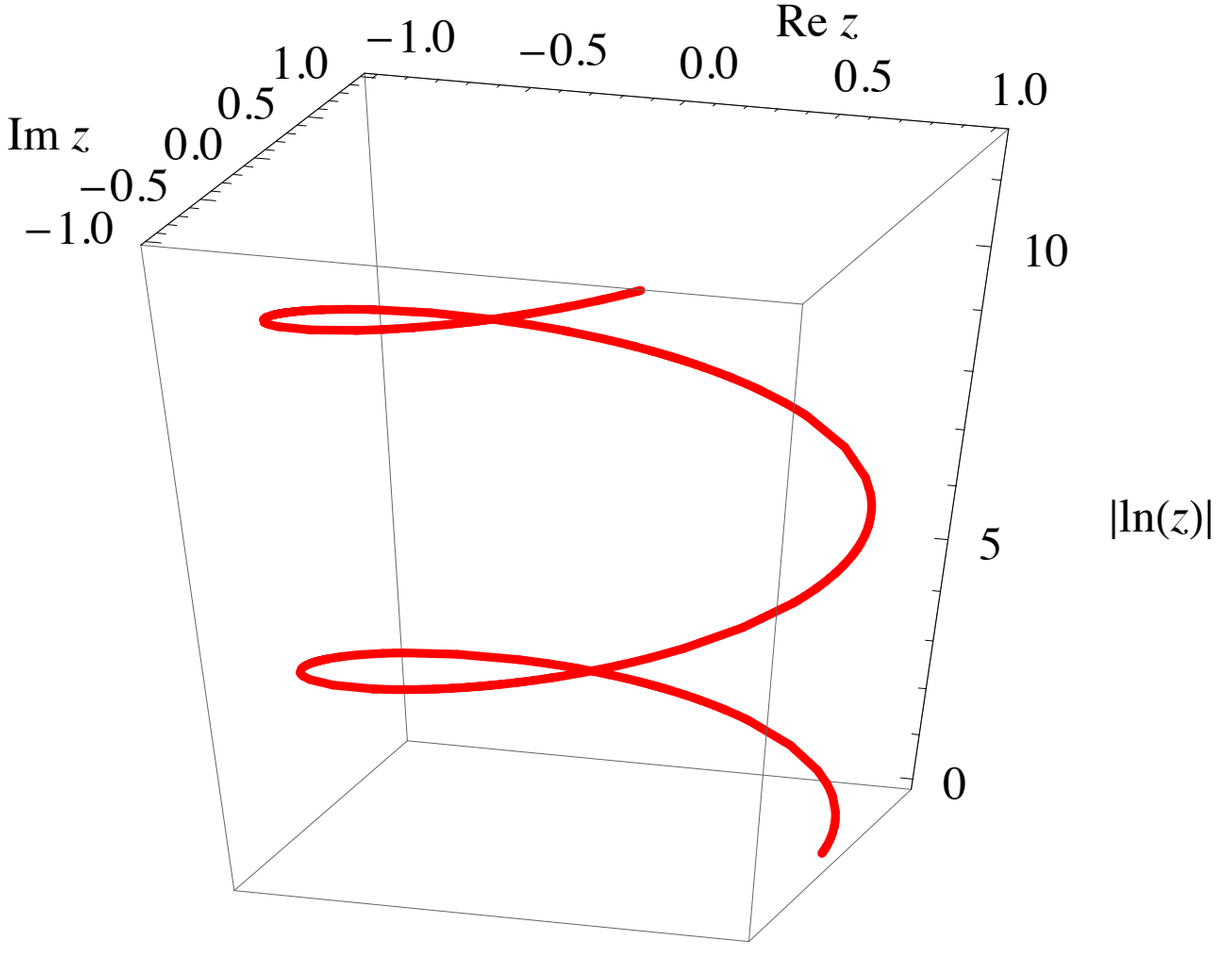
periodic

called " $V(\phi)$ has a monodromy in ϕ "

- we have seen this:

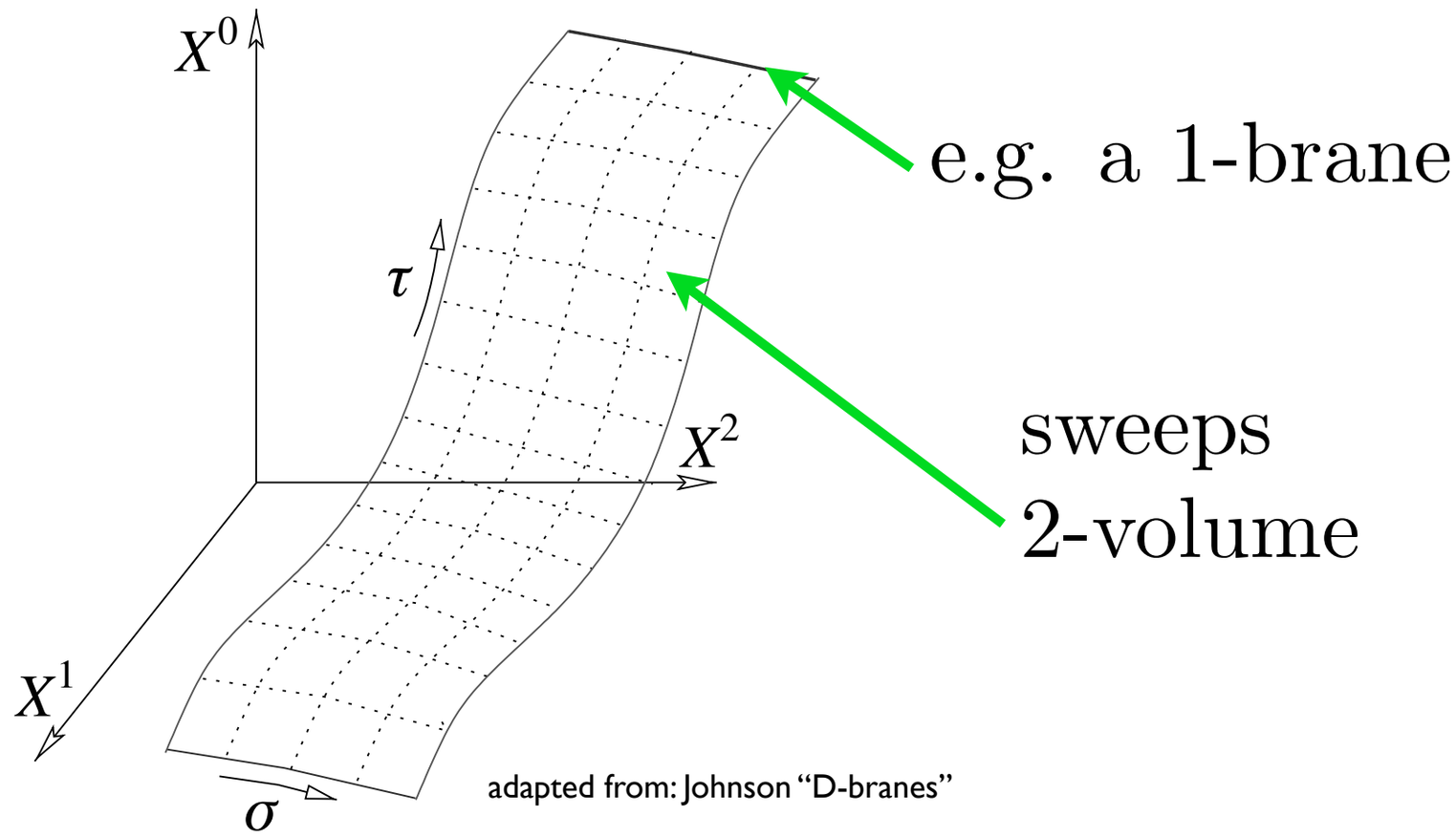
think of

$$|\ln z|, \quad z = e^{i\phi}$$



how to do this ...

- we can get a monodromy in $V(\phi)$ from branes:



adapted from: Johnson "D-branes"

$$S \sim \frac{1}{g_s} \int d\,\text{volume} \;=\; \frac{1}{g_s} \int d^2\xi \sqrt{-\det G}$$

$$\text{if with } B_2\text{:}\;\; S \sim \frac{1}{g_s} \int d^2\xi \sqrt{-\det(G + B_2)}$$