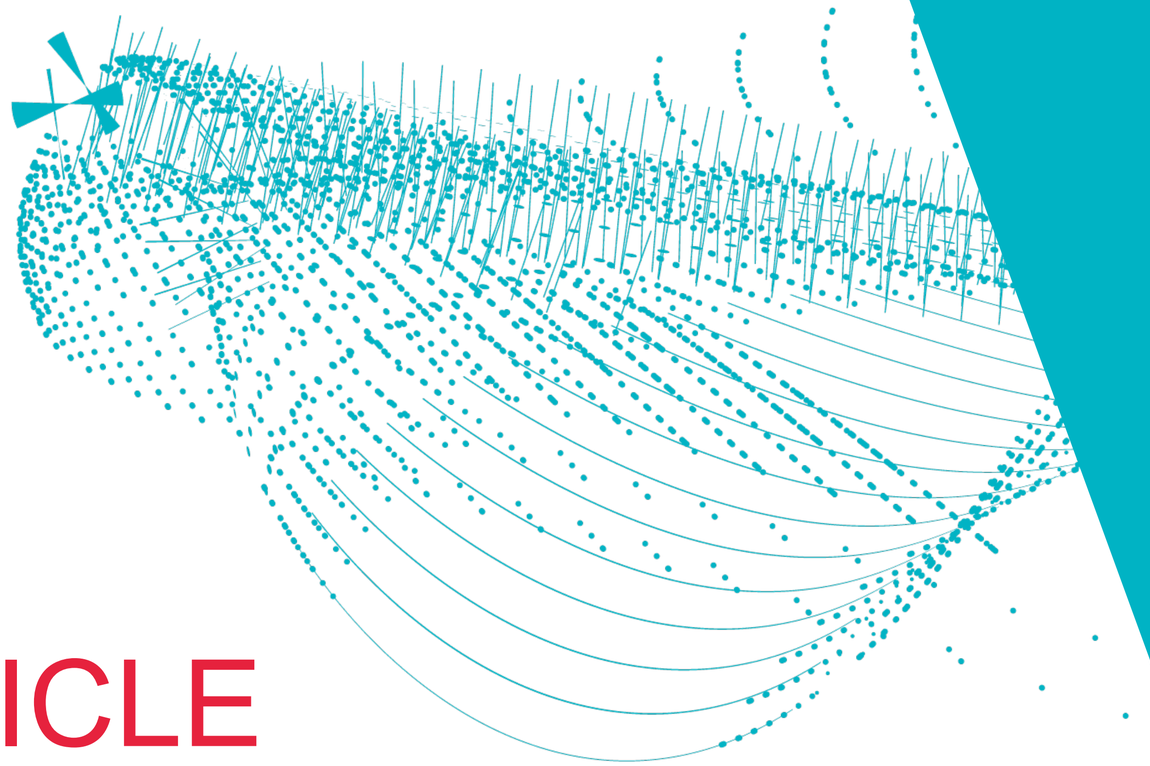
Nikhef



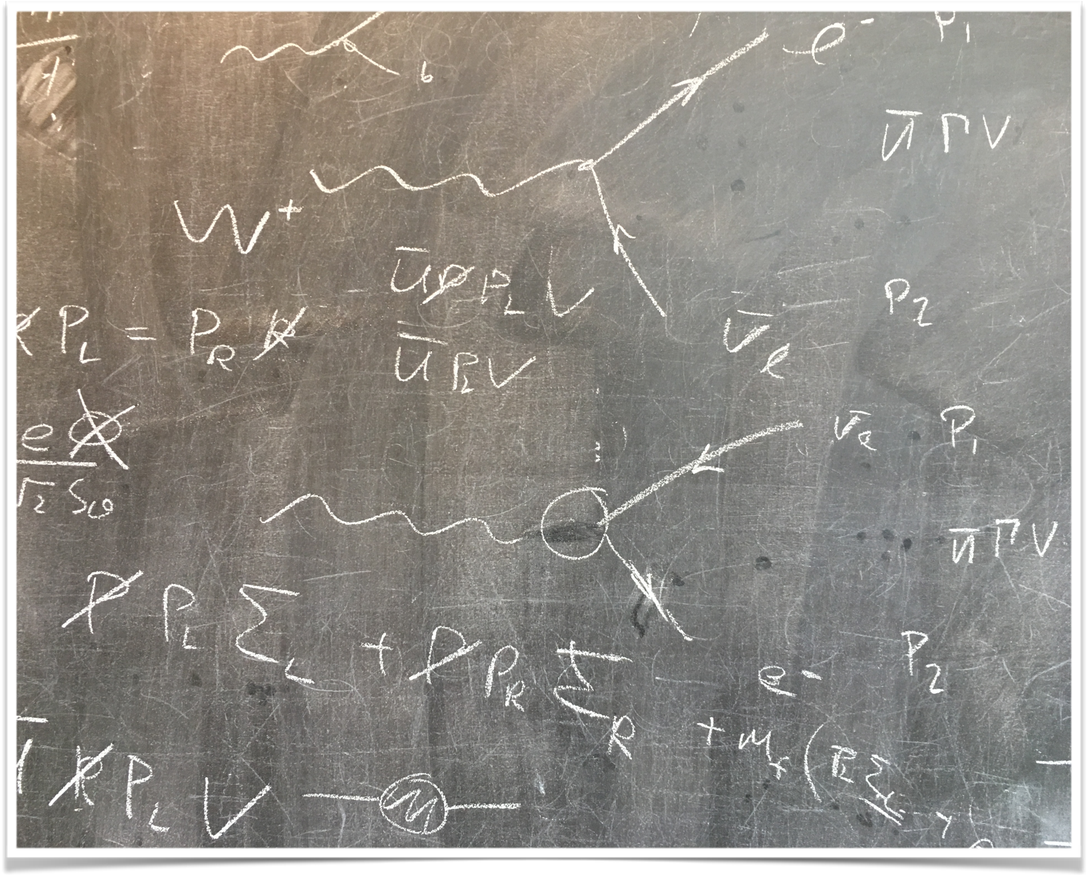
RECFA MEETING, 19 OCTOBER 2018

THEORETICAL PARTICLE PHYSICS LANDSCAPE IN THE NETHERLANDS

Robert Fleischer

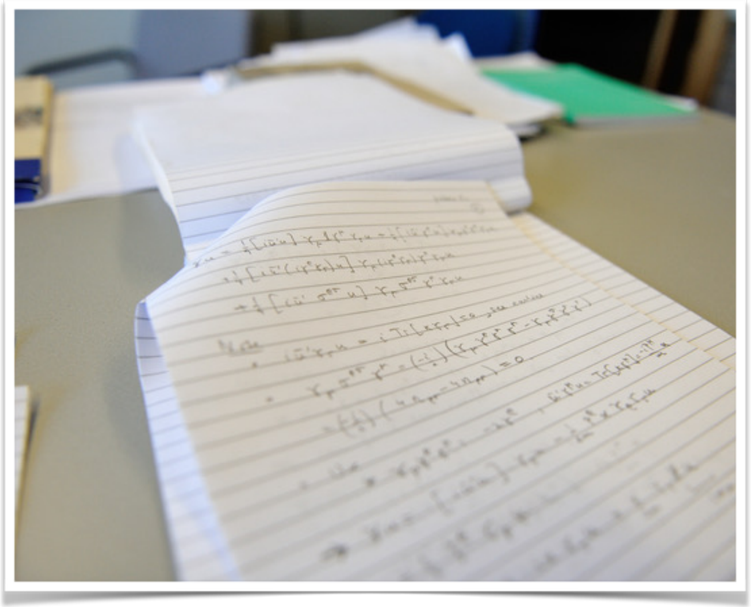
OUTLINE

- Preliminaries
- Nikhef Theory Group Amsterdam
- Dutch Theory Landscape
- Education in Theoretical Physics
- Theory Networks and Initiatives
- Funding and Opportunities
- Outlook



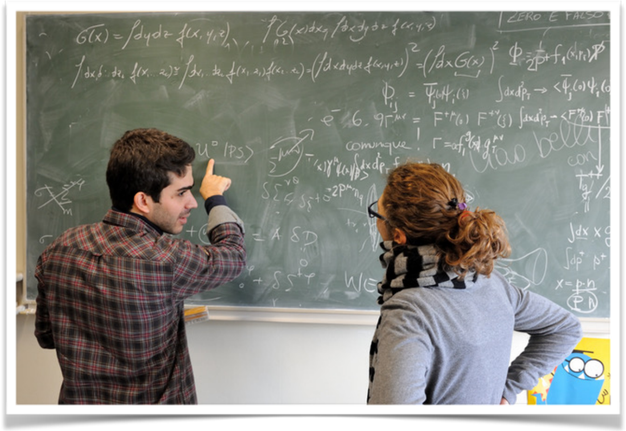
HOW DO THEORISTS WORK?

- Typically collaborations of about 1-10 people.
- Involvement of students, postdocs and staff.
- The Netherlands as a small country allows a lot of interaction between different groups.
- Nikhef provides a *very stimulating setting*, also for theorists, leading sometimes to joint projects between theory and experiment.



THEORY “HARDWARE”

- Paper and pens + pencils
- Computers
- Coffee (!)
- Personpower
- Blackboards for discussions …



DUTCH THEORETICAL PARTICLE PHYSICS

- Amsterdam: Nikhef, VU, UvA
- Nijmegen: Radboud Universiteit
- Groningen: Rijksuniversiteit
- Utrecht: Universiteit Utrecht
- Leiden: Universiteit Leiden

[Nikhef Theory Groups]

- *Large community:*
  - O(45) staff members
  - O(60) postdocs
  - O(100) PhD students

[No theoretical particle physics at Technical Universities]

NIKHEF THEORY GROUP AMSTERDAM

- Broad spectrum of research topics:
  - QCD and collider physics
  - Flavour physics
  - Dark matter
  - Cosmology
- Serves as a national centre for particle physics phenomenology
- Exploit environment at Nikhef through close interactions with the experimental groups

NIKHEF THEORY GROUP AMSTERDAM: LEADERSHIP

- Head of the group from 2005-2018:

  Eric Laenen

  - Largely shaped Nikhef theory
  - Initiated collaborations within our community
  - Conducted two FOM programmes
  - Stimulated also a lot of further success in acquiring external funding (FOM, NWO, ERC grants, …)

  → *Many thanks to Eric!*

- Since September 2018: R.F. (… giving this talk)

NIKHEF THEORY AMSTERDAM: PEOPLE

- Staff members:
  - Robert Fleischer (+VU): flavour physics
  - Eric Laenen (+UvA+UU): QCD, collider
  - Piet Mulders (VU): QCD
  - Marieke Postma: cosmology
  - Juan Rojo (VU): QCD, LHC pheno
  - Bert Schellekens: string theory
  - Wouter Waalewijn (UvA): QCD, collider
- Junior staff members:
  - Franz Herzog (Vidi): higher orders, Higgs
  - Kalliopi Petraki (Vidi+Paris): dark matter

- (Formally) retired staff members:
  - Jos Vermaseren: FORM
  - Jan-Willem van Holten: BSM, gravitational waves
  - Bernard de Wit (+UU): string theory, black holes

NIKHEF THEORY AMSTERDAM: PEOPLE

- Postdocs:

- PhD:

- MSc:

+ many new arrivals …

IMPORTANT LINKS TO UNIVERSITIES

“Bijzonder hooglераren”

- Professorships by special appointment:
  - Wim Beenakker: *Universiteit van Amsterdam*
  - Robert Fleischer: *Vrije Universiteit Amsterdam*
  - Jan-Willem van Holten: *Universiteit Leiden*
  - Bert Schellekens: *Radboud Universiteit Nijmegen*

- This is a very beneficial scheme:
  - Teaching, usually at the MSc level, access to students…
  - Promotors for PhD Students

NIKHEF THEORY A'DAM: *RESEARCH HIGHLIGHTS*

Selection:

- NNNLO Higgs production
- QCD resummation
- B decays
- Colour entanglement
- Dark matter bound states
- Supergravity
- String theory landscape

FLAGSHIP PROJECT: FORM

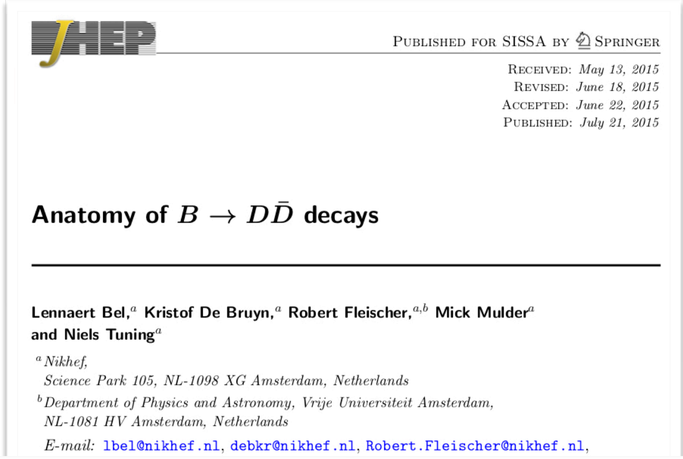
- Developed by Jos Vermaseren:
  - Computer Algebra Program
  - 1984-now: currently version 4.2
- Various (N)NLO calculations
  - 5-loop beta function (!)
  - 3- and 4-loop splitting functions, …
- Crucial to secure the future of form:
  - Open source code available (GitHUB + forum)
  - Share the knowledge among the physicists
  - Aim at dedicated/shared/European funding/project, having broader support from the community

INTERACTION THEORY-EXPERIMENT

Utilise the Structure of Nikhef:

- Theorists learn about experimental challenges, may point out new observables, …
- Excellent experience with joint grants and PhD projects (with LHCb, ATLAS and Virgo)
- Joint papers Theory-Experiment
- Initiative “Theory meets Experiment”:
  - Theory colloquium with informal mini-workshop
  - Rare B decays, axions, lepton flavour violation, …

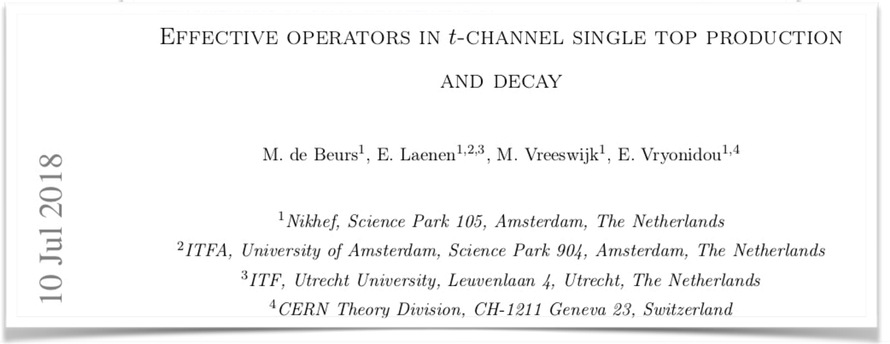
[R.F., Marcel Merk (LHCb), Olya Igonkina (ATLAS)]


JHEP
Published for SISSA by Springer
Received: May 13, 2015
Revised: June 18, 2015
Accepted: June 22, 2015
Published: July 21, 2015

Anatomy of $B \to D\bar{D}$ decays

Lennaert Bel,[a] Kristof De Bruyn,[a] Robert Fleischer,[a,b] Mick Mulder[a] and Niels Tuning[a]

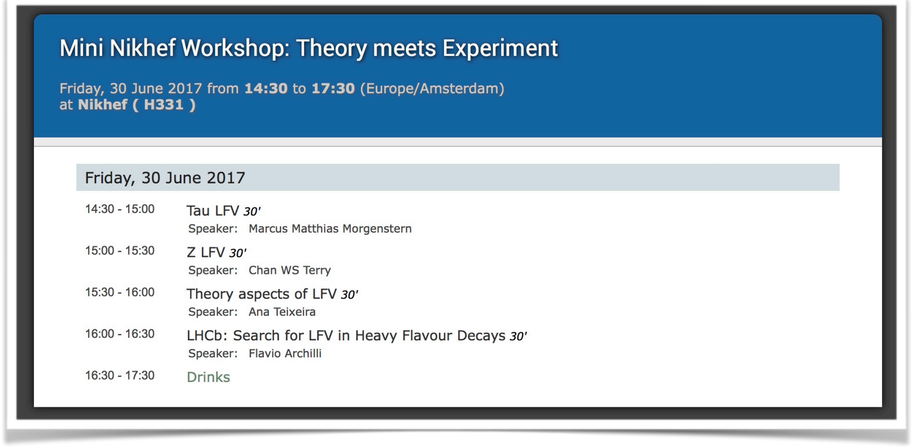
[a] Nikhef, Science Park 105, NL-1098 XG Amsterdam, Netherlands
[b] Department of Physics and Astronomy, Vrije Universiteit Amsterdam, NL-1081 HV Amsterdam, Netherlands
E-mail: lbel@nikhef.nl, debkr@nikhef.nl, Robert.Fleischer@nikhef.nl,


10 Jul 2018

Effective operators in t-channel single top production and decay

M. de Beurs[1], E. Laenen[1,2,3], M. Vreeswijk[1], E. Vryonidou[1,4]

[1] Nikhef, Science Park 105, Amsterdam, The Netherlands
[2] ITFA, University of Amsterdam, Science Park 904, Amsterdam, The Netherlands
[3] ITF, Utrecht University, Leuvenlaan 4, Utrecht, The Netherlands
[4] CERN Theory Division, CH-1211 Geneva 23, Switzerland


Mini Nikhef Workshop: Theory meets Experiment

Friday, 30 June 2017 from **14:30** to **17:30** (Europe/Amsterdam)
at **Nikhef (H331)**

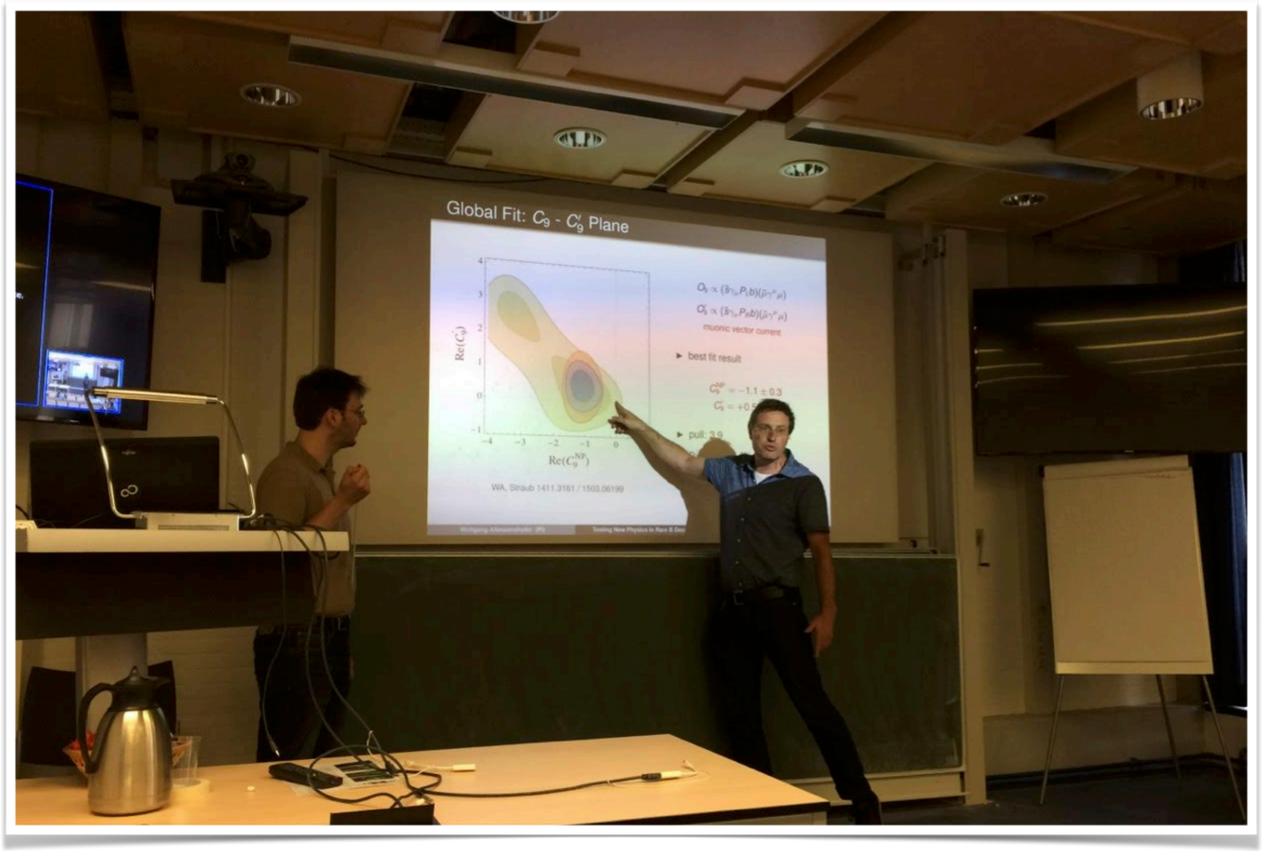
Friday, 30 June 2017

14:30 - 15:00	Tau LFV *30'*	Speaker: Marcus Matthias Morgenstern
15:00 - 15:30	Z LFV *30'*	Speaker: Chan WS Terry
15:30 - 16:00	Theory aspects of LFV *30'*	Speaker: Ana Teixeira
16:00 - 16:30	LHCb: Search for LFV in Heavy Flavour Decays *30'*	Speaker: Flavio Archilli
16:30 - 17:30	Drinks	

INTERACTION THEORY-EXPERIMENT @ NIKHEF

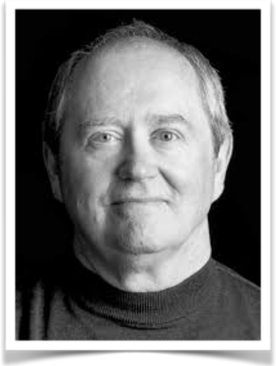
★ Theory meets Experiment:

Marcel Merk (LHCb) discussing with Wolfgang Altmannshofer about rare B decay anomalies …



NIKHEF THEORY AMSTERDAM: VISITORS

- Important element of our scientific life:
  - Rohini Godbole (Bangalor)
  - Chris Quigg (Fermilab)
  - Lorenzo Magnea (Torino)
  - Herbert Dreiner (Bonn)
  - Yoshimasa Kurihara (KEK)
  - Ya-jin Zhou (Shandong)
  - Asmita Mukherjee (Mumbai)
  - Robert Harlander (Aachen)
  - + …
- Interactions also with postdocs and students, give colloquia, seminars, lectures, sometimes joint papers.





WORKSHOPS AND CONFERENCES

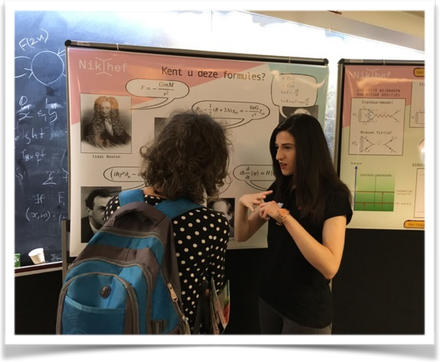
- The Nikhef theory group is actively involved in the organisations of workshops in Amsterdam

- Recent examples:
  - Jos Fest (2015)
  - SM@LHC2017
  - SCET 2018
  - Tau 2018
  - NNPDF Collaboration Meetings

OUTREACH @ NIKHEF THEORY

Various activities, just some highlights:

- Nikhef Open Day:
  - “Ask a Big Bang Theorist” [R.F.+…]
- On television:
  - Melissa van Beekveld
- Lectures for general audiences:
  - At schools and for elderly [v. Holten, Mulders]
- Higgs outreach:
  - Eric Laenen, Piet Mulders
- Involvement in HiSPARC



FUNDING @ NIKHEF THEORY AMSTERDAM

- Individual grants:
  - FOM projectruimte grants
  - Veni, Vidi grants
  - ERC grants

- (FOM) NWO programme:
  - Running: *Higgs as a Probe and Portal*
  - Consortium plays essential role!

→ *Key funding for our postdocs + PhD students*

FUNDING @ NIKHEF THEORY AMSTERDAM

- Continuous funding efforts:

  → *Snapshots …*

- O(125) grant applications since 2007 with remarkable success:
  - 3 ERC advanced grants
  - 2 ERC starting grants
  - 3 Vidi grants
  - 7 Veni and Marie Curie grants
  - + …

[Since 2011]

Vidi	Fall 2014
Veni	Januari 2015
Veni	Januari 2015
Veni	Januari 2015
H2020 ITN #PRECISION	Januari 2015
ERC junior	Januari 2015
E-Cost network	Spring 2015
E-Cost network	Fall 2015
RISE	Spring 2015
Niels Stensen Fellowship	Fall 2015
Vici	Spring 2015
Projectruimte	Voorjaar 2015
MC IF Re-integration	Sept. 2015
MC IF	Sept. 2015
D-ITP PhD grant	10/1/2015
Vici	Spring 2016
H2020 ETN #PRECISION	Januari 2016
RISE	Spring 2016
Projectruimte	Winter 2015-2016
Projectruimte	Winter 2015-2016
Marie Curie	Sept. 2016
Marie Curie (Global F)	Sept. 2016
Marie Curie	Sept. 2016
Marie Curie	Sept. 2016
Marie Curie	Sept.. 2016
ERC starting grant	Sept. 2016
Vidi	Oct. 6
D-ITP PhD grant	Oct. 6
Projectruimte	Oct. 1
ITN HiggsTrain	Jan. 10
ITN Precision	Jan. 10
IoP special PhD position	Jan. 9
IoP special PhD position	Jan. 9

Vidi	Fall 2017
Vidi	Fall 2017
Vidi	Fall 2017
Vidi	Fall 2017
ERC starting grant	Fall 2017
MC-IF	Fall 2017
MC-IF	Fall 2017
MC-IF	Fall 2017
ERC Advanced Grant	Fall 2017
ITN "Collisions"	Jan 2018
Veni	Jan 2018
ERC Consolidator	2018
Projectruimte	Spring 2018
Projectruimte	Spring 2018
Projectruimte	Spring 2018
ERC Advanced Grant	August 2018
Vidi	Fall 2018
Zwaartekracht (RU & UvA)	Fall 2018
Simons Foundation	Fall 2018
ERC Starting grant	Fall 2019
ERC Starting grant	Fall 2019
NWO ENW Groot grant	Spring 2019

DUTCH THEORY LANDSCAPE / OTHER GROUPS

- Various activities, many people
- Focus on staff members (about 45)
- Sketch of the main research topics

VRIJE UNIVERSITEIT AMSTERDAM

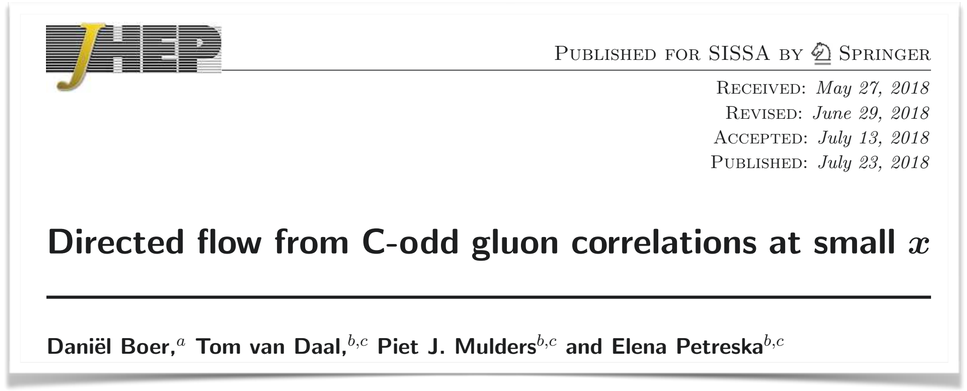
- Piet Mulders:
  - Gluon PDF including transverse momentum dependence, linearly polarised gluons
  - Links to EIC developments in the US
  - New initiative “Emergence of Symmetries in the SM”

- Juan Rojo (+2015):
  - Precision QCD for neutrino telescopes
  - Evidence for BFKL dynamics in HERA data
  - Model-independent fragmentation functions

Essentially @ Nikhef

VRIJE UNIVERSITEIT AMSTERDAM

Selection of Research Highlights:



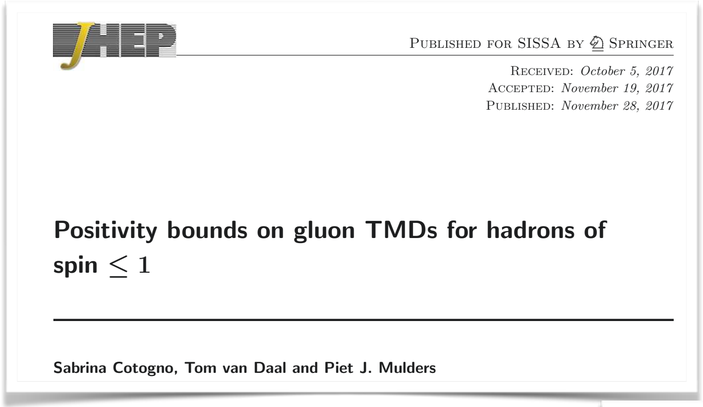
JHEP

Published for SISSA by Springer

Received: *May 27, 2018*
Revised: *June 29, 2018*
Accepted: *July 13, 2018*
Published: *July 23, 2018*

Directed flow from C-odd gluon correlations at small x

Daniël Boer,[a] Tom van Daal,[b,c] Piet J. Mulders[b,c] and Elena Petreska[b,c]



JHEP

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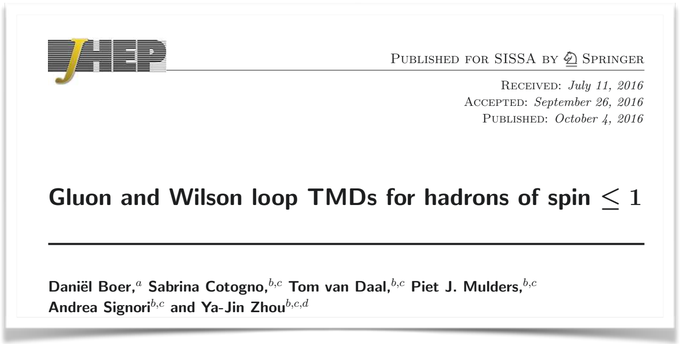
Received: *October 5, 2017*
Accepted: *November 19, 2017*
Published: *November 28, 2017*

Positivity bounds on gluon TMDs for hadrons of spin ≤ 1

Sabrina Cotogno, Tom van Daal and Piet J. Mulders



JHEP

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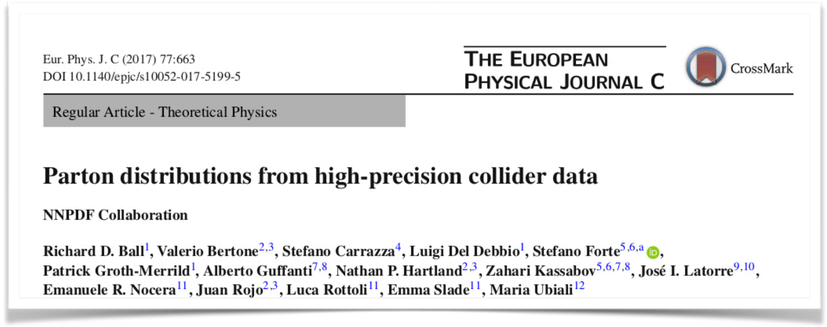
Received: *July 11, 2016*
Accepted: *September 26, 2016*
Published: *October 4, 2016*

Gluon and Wilson loop TMDs for hadrons of spin ≤ 1

Daniël Boer,[a] Sabrina Cotogno,[b,c] Tom van Daal,[b,c] Piet J. Mulders,[b,c] Andrea Signori[b,c] and Ya-Jin Zhou[b,c,d]



Eur. Phys. J. C (2017) 77:663
DOI 10.1140/epjc/s10052-017-5199-5

THE EUROPEAN PHYSICAL JOURNAL C

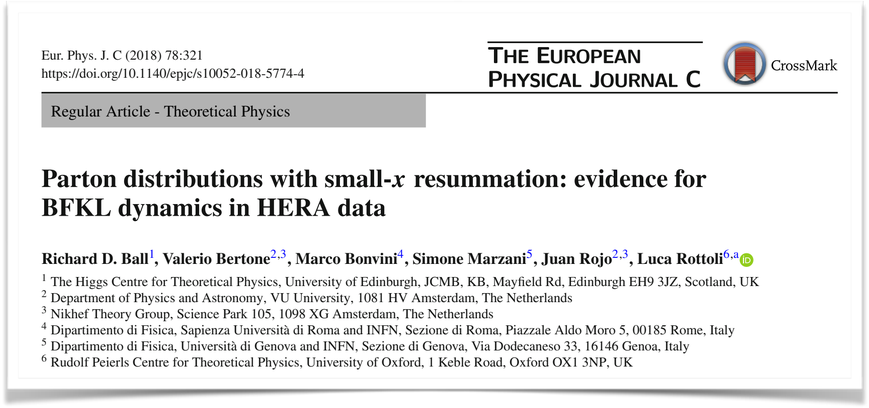
CrossMark

Regular Article - Theoretical Physics

Parton distributions from high-precision collider data

NNPDF Collaboration

Richard D. Ball[1], Valerio Bertone[2,3], Stefano Carrazza[4], Luigi Del Debbio[1], Stefano Forte[5,6,a], Patrick Groth-Merrild[1], Alberto Guffanti[7,8], Nathan P. Hartland[2,3], Zahari Kassabov[5,6,7,8], José I. Latorre[9,10], Emanuele R. Nocera[11], Juan Rojo[2,3], Luca Rottoli[11], Emma Slade[11], Maria Ubiali[12]



Eur. Phys. J. C (2018) 78:321
https://doi.org/10.1140/epjc/s10052-018-5774-4

THE EUROPEAN PHYSICAL JOURNAL C

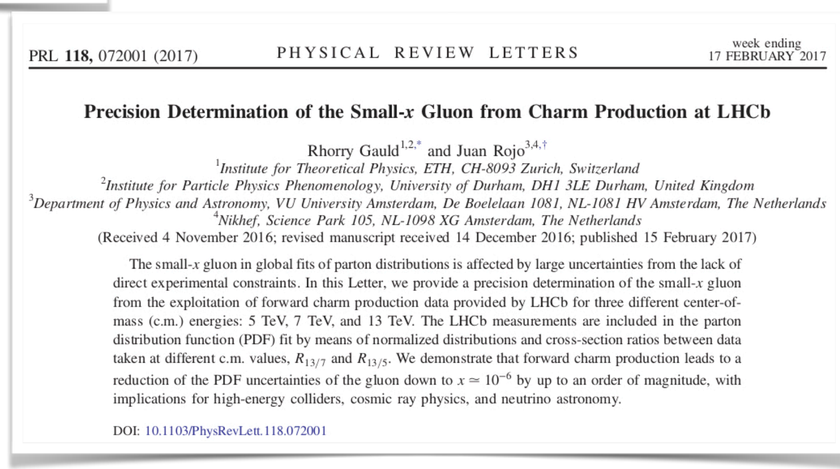
CrossMark

Regular Article - Theoretical Physics

Parton distributions with small-x resummation: evidence for BFKL dynamics in HERA data

Richard D. Ball[1], Valerio Bertone[2,3], Marco Bonvini[4], Simone Marzani[5], Juan Rojo[2,3], Luca Rottoli[6,a]

[1] The Higgs Centre for Theoretical Physics, University of Edinburgh, JCMB, KB, Mayfield Rd, Edinburgh EH9 3JZ, Scotland, UK
[2] Department of Physics and Astronomy, VU University, 1081 HV Amsterdam, The Netherlands
[3] Nikhef Theory Group, Science Park 105, 1098 XG Amsterdam, The Netherlands
[4] Dipartimento di Fisica, Sapienza Università di Roma and INFN, Sezione di Roma, Piazzale Aldo Moro 5, 00185 Rome, Italy
[5] Dipartimento di Fisica, Università di Genova and INFN, Sezione di Genova, Via Dodecaneso 33, 16146 Genoa, Italy
[6] Rudolf Peierls Centre for Theoretical Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, UK



PRL **118,** 072001 (2017) PHYSICAL REVIEW LETTERS week ending 17 FEBRUARY 2017

Precision Determination of the Small-x Gluon from Charm Production at LHCb

Rhorry Gauld[1,2,*] and Juan Rojo[3,4,†]

[1]*Institute for Theoretical Physics, ETH, CH-8093 Zurich, Switzerland*
[2]*Institute for Particle Physics Phenomenology, University of Durham, DH1 3LE Durham, United Kingdom*
[3]*Department of Physics and Astronomy, VU University Amsterdam, De Boelelaan 1081, NL-1081 HV Amsterdam, The Netherlands*
[4]*Nikhef, Science Park 105, NL-1098 XG Amsterdam, The Netherlands*

(Received 4 November 2016; revised manuscript received 14 December 2016; published 15 February 2017)

The small-x gluon in global fits of parton distributions is affected by large uncertainties from the lack of direct experimental constraints. In this Letter, we provide a precision determination of the small-x gluon from the exploitation of forward charm production data provided by LHCb for three different center-of-mass (c.m.) energies: 5 TeV, 7 TeV, and 13 TeV. The LHCb measurements are included in the parton distribution function (PDF) fit by means of normalized distributions and cross-section ratios between data taken at different c.m. values, $R_{13/7}$ and $R_{13/5}$. We demonstrate that forward charm production leads to a reduction of the PDF uncertainties of the gluon down to $x \simeq 10^{-6}$ by up to an order of magnitude, with implications for high-energy colliders, cosmic ray physics, and neutrino astronomy.

DOI: 10.1103/PhysRevLett.118.072001

RADBOUD UNIVERSITEIT NIJMEGEN

Phenomenology

- Wim Beenakker:
  - Resummation
  - Supersymmetry
  - Dark Matter

- Sascha Caron (ATLAS):
  - Supersymmetry
  - Dark Matter
  - Machine Learning

- Ronald Kleiss:
  - Collider Physics
  - Renormalization
  - Monte Carlo

- Tom Rijken (retired):
  - Nuclear Physics
  - Neutron Stars

RADBOUD UNIVERSITEIT NIJMEGEN

Phenomenology: selection of research highlights

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RECEIVED: *August 9, 2016*
REVISED: *November 25, 2016*
ACCEPTED: *November 26, 2016*
PUBLISHED: *December 23, 2016*

NNLL-fast: predictions for coloured supersymmetric particle production at the LHC with threshold and Coulomb resummation

Wim Beenakker,[a,b] Christoph Borschensky,[c] Michael Krämer,[d] Anna Kulesza[e] and Eric Laenen[f,g,h]

PUBLISHED FOR SISSA BY SPRINGER
RECEIVED: *September 19, 2017*
REVISED: *November 13, 2017*
ACCEPTED: *November 20, 2017*
PUBLISHED: *November 27, 2017*

Final-state QED multipole radiation in antenna parton showers

Ronald Kleiss and Rob Verheyen

PHYSICAL REVIEW D **96,** 035015 (2017)

Supersymmetry with dark matter is still natural

Melissa van Beekveld,[1,*] Wim Beenakker,[1,2,†] Sascha Caron,[1,3,‡] Ruud Peeters,[4,§] and Roberto Ruiz de Austri[5,‖]
[1]*Institute for Mathematics, Astrophysics and Particle Physics, Faculty of Science, Mailbox 79, Radboud University Nijmegen, P.O. Box 9010, NL-6500 GL Nijmegen, Netherlands*
[2]*Institute of Physics, University of Amsterdam, Science Park 904, 1018 XE Amsterdam, Netherlands*
[3]*Nikhef, Science Park 110, 1098 XG Amsterdam, Netherlands*
[4]*Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, Nijenborgh 4, 9747 AG Groningen, Netherlands*
[5]*Instituto de Física Corpuscular, IFIC-UV/CSIC, C/Catedrático José Beltrán, E-46980 Paterna, Valencia, Spain*
(Received 23 January 2017; revised manuscript received 16 May 2017; published 17 August 2017)

We identify the parameter regions of the phenomenological minimal supersymmetric standard model (pMSSM) with the minimal possible fine-tuning. We show that the fine-tuning of the pMSSM is not large, nor under pressure by LHC searches. Low sbottom, stop and gluino masses turn out to be less relevant for low fine-tuning than commonly assumed. We show a link between low fine-tuning and the dark matter relic density. Fine-tuning arguments point to models with a dark matter candidate yielding the correct dark matter relic density: a bino-higgsino particle with a mass of 35–155 GeV. Some of these candidates are compatible with recent hints seen in astrophysics experiments such as Fermi-LAT and AMS-02. We argue that upcoming direct search experiments, such as XENON1T, will test all of the most natural solutions in the next few years due to the sensitivity of these experiments on the spin-dependent WIMP-nucleon cross section.

Shell graduation prize 2016: Melissa van Beekveld (PhD)

PUBLISHED FOR SISSA BY SPRINGER
RECEIVED: *July 14, 2015*
REVISED: *September 11, 2015*
ACCEPTED: *September 14, 2015*
PUBLISHED: *October 2, 2015*

Renormalization group invariants in supersymmetric theories: one- and two-loop results

Wim Beenakker,[a,b] Tom van Daal,[c,d] Ronald Kleiss[a] and Rob Verheyen[a]

PUBLISHED FOR SISSA BY SPRINGER
RECEIVED: *February 24, 2016*
ACCEPTED: *April 20, 2016*
PUBLISHED: *April 26, 2016*

The case for 100 GeV bino dark matter: a dedicated LHC tri-lepton search

Melissa van Beekveld,[a] Wim Beenakker,[a,b] Sascha Caron[a,c] and Roberto Ruiz de Austri[d]

RADBOUD UNIVERSITEIT NIJMEGEN

Quantum Gravity: first principles…

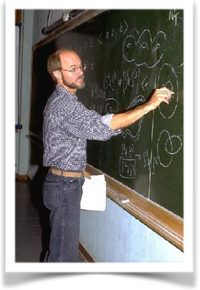
- Renate Loll:
  - Constructing space time bottom up
  - Microscopic constituents of space time
  - Numerical simulations

- Frank Saueressig:
  - Towards quantum theory of gravity
  - Renormalisation group analyses

- Timothy Budd (+2018):
  - Mathematical tools, numerical methods
  - Structure of spacetime at smallest scales

→ *(FOM) Programme: Search for quantum space time*

- Jan Ambjørn (affiliate NBI):
  - Quantum gravity
  - String theory



RADBOUD UNIVERSITEIT NIJMEGEN

Quantum Gravity: selection of research highlights

PHYSICAL REVIEW D **97,** 106017 (2018)

Implementing quantum Ricci curvature

N. Klitgaard* and R. Loll†
Institute for Mathematics, Astrophysics and Particle Physics, Radboud University, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

(Received 28 February 2018; published 21 May 2018)

Quantum Ricci curvature has been introduced recently as a new, geometric observable characterizing the curvature properties of metric spaces, without the need for a smooth structure. Besides coordinate invariance, its key features are scalability, computability, and robustness. We demonstrate that these properties continue to hold in the context of nonperturbative quantum gravity, by evaluating the quantum Ricci curvature numerically in two-dimensional Euclidean quantum gravity, defined in terms of dynamical triangulations. Despite the well-known, highly nonclassical properties of the underlying quantum geometry, its Ricci curvature can be matched well to that of a five-dimensional round sphere.

PHYSICAL REVIEW D **97,** 046008 (2018)

Introducing quantum Ricci curvature

N. Klitgaard[1,*] and R. Loll[1,2,†]
[1]*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands*
[2]*Perimeter Institute for Theoretical Physics, 31 Caroline Street North, Waterloo, Ontario N2L 2Y5, Canada*

(Received 31 December 2017; published 15 February 2018)

Motivated by the search for geometric observables in nonperturbative quantum gravity, we define a notion of coarse-grained Ricci curvature. It is based on a particular way of extracting the local Ricci curvature of a smooth Riemannian manifold by comparing the distance between pairs of spheres with that of their centers. The quantum Ricci curvature is designed for use on non-smooth and discrete metric spaces, and to satisfy the key criteria of scalability and computability. We test the prescription on a variety of regular and random piecewise flat spaces, mostly in two dimensions. This enables us to quantify its behavior for short lattices distances and compare its large-scale behavior with that of constantly curved model spaces. On the triangulated spaces considered, the quantum Ricci curvature has good averaging properties and reproduces classical characteristics on scales large compared to the discretization scale.

PRL **113,** 171101 (2014) PHYSICAL REVIEW LETTERS week ending 24 OCTOBER 2014

Asymptotic Freedom in Hořava-Lifshitz Gravity

Giulio D'Odorico, Frank Saueressig, and Marrit Schutten
Radboud University Nijmegen, Institute for Mathematics, Astrophysics and Particle Physics, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands
(Received 18 July 2014; published 20 October 2014)

We use the Wetterich equation for foliated spacetimes to study the renormalization group flow of projectable Hořava-Lifshitz gravity coupled to n Lifshitz scalars. Using novel results for anisotropic heat kernels, the matter-induced beta functions for the gravitational couplings are computed explicitly. The renormalization group flow exhibits an UV attractive anisotropic Gaussian fixed point where Newton's constant vanishes and the extra scalar mode decouples. This fixed point ensures that the theory is asymptotically free in the large–n expansion, indicating that projectable Hořava-Lifshitz gravity is perturbatively renormalizable. Notably, the fundamental fixed point action does not obey detailed balance.

DOI: 10.1103/PhysRevLett.113.171101 PACS numbers: 04.50.Kd, 04.60.-m, 05.10.Cc

JHEP PUBLISHED FOR SISSA BY SPRINGER
RECEIVED: *August 18, 2015*
ACCEPTED: *September 23, 2015*
PUBLISHED: *October 20, 2015*

Covariant computation of effective actions in Hořava-Lifshitz gravity

Giulio D'Odorico, Jan-Willem Goossens and Frank Saueressig

IOPscience Journals Books Publishing Support Login

Classical and Quantum Gravity

PAPER

Renormalization group flow in CDT

J Ambjørn[1,2], A Görlich[1,3], J Jurkiewicz[3], A Kreienbuehl[2,4] and R Loll[2,5]

Published 25 July 2014 • © 2014 IOP Publishing Ltd
Classical and Quantum Gravity, Volume 31, Number 16

PHYSICAL REVIEW D **92,** 124068 (2015)

Quantum phase transitions in the Belinsky-Khalatnikov-Lifshitz universe

Giulio D'Odorico* and Frank Saueressig†
Radboud University Nijmegen, Institute for Mathematics, Astrophysics and Particle Physics, Heyendaalseweg 135, 6525 AJ Nijmegen, Netherlands
(Received 12 November 2015; published 30 December 2015)

We study quantum corrections to the classical Bianchi I and Bianchi IX universes. The modified dynamics is well motivated from the asymptotic safety program where the short-distance behavior of gravity is governed by a nontrivial renormalization group fixed point. The correction terms induce a phase transition in the dynamics of the model, changing the classical, chaotic Kasner oscillations into a uniform approach to a point singularity. The resulting implications for the microscopic structure of spacetime are discussed.

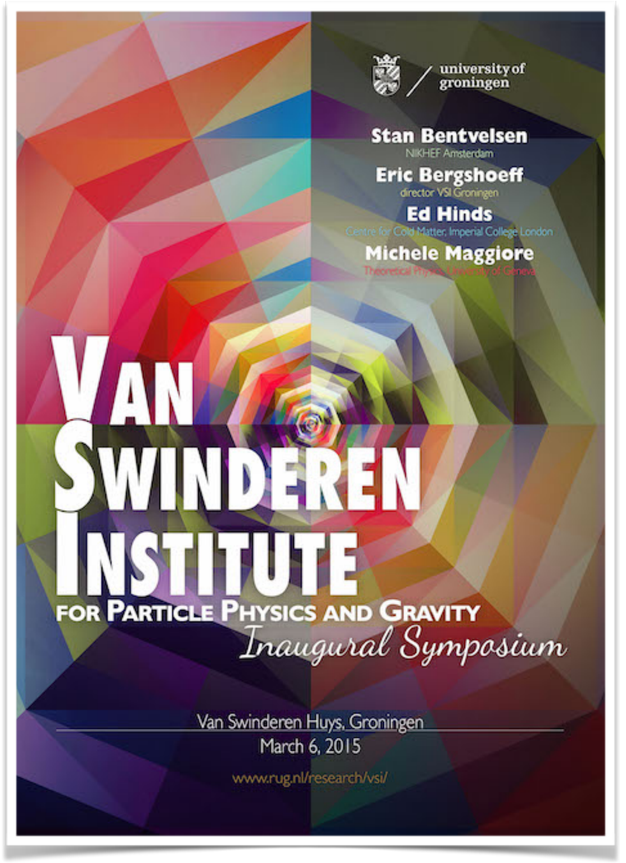
RIJKSUNIVERSITEIT GRONINGEN

rijksuniversiteit groningen

Nikhef

Van Swinderen Institute has joined Nikhef (2016)

★ Experiment and *theory*…



RIJKSUNIVERSITEIT GRONINGEN

Nikhef

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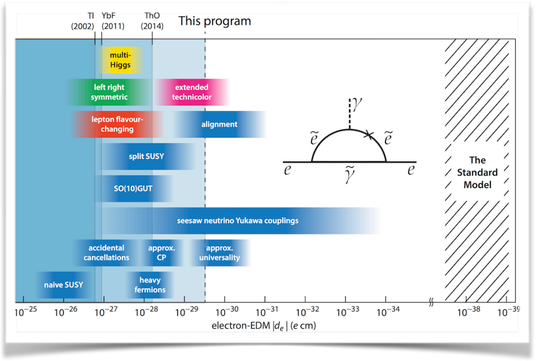
Particle Phenomenology

- Daniel Boer:
  - QCD, collider physics, BSM

- Elisabetta Pallante:
  - SM and beyond, flavour physics, lattice QCD, conformal field theory

- Rob Timmermans:
  - EDMs, Lorentz violation

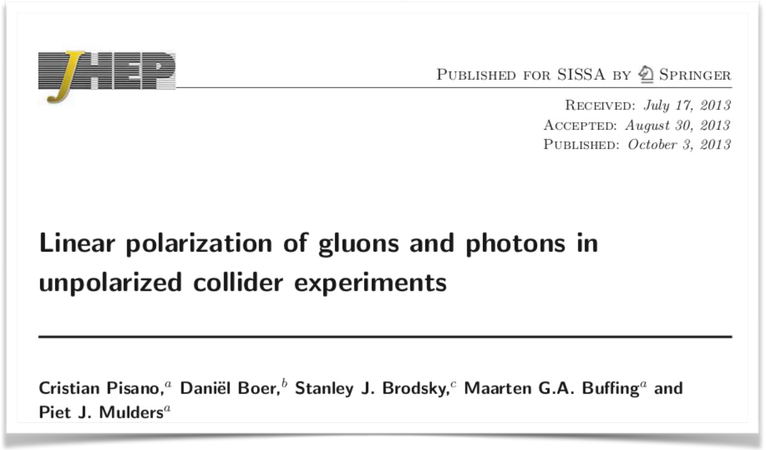
- Anupam Mazumdar (+2016):
  - Cosmology, BSM, quantum gravity



- Steven Hoekstra:
  - Electron EDM experiment
- Hans Wilschut (LHCb, retired):
  - Tests of Lorentz and CPT symmetries

RIJKSUNIVERSITEIT GRONINGEN

Particle Phenomenology: selection of research highlights



JHEP

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Published: *October 3, 2013*

Linear polarization of gluons and photons in unpolarized collider experiments

Cristian Pisano,[a] Daniël Boer,[b] Stanley J. Brodsky,[c] Maarten G.A. Buffing[a] and Piet J. Mulders[a]

JHEP

Published for SISSA by Springer

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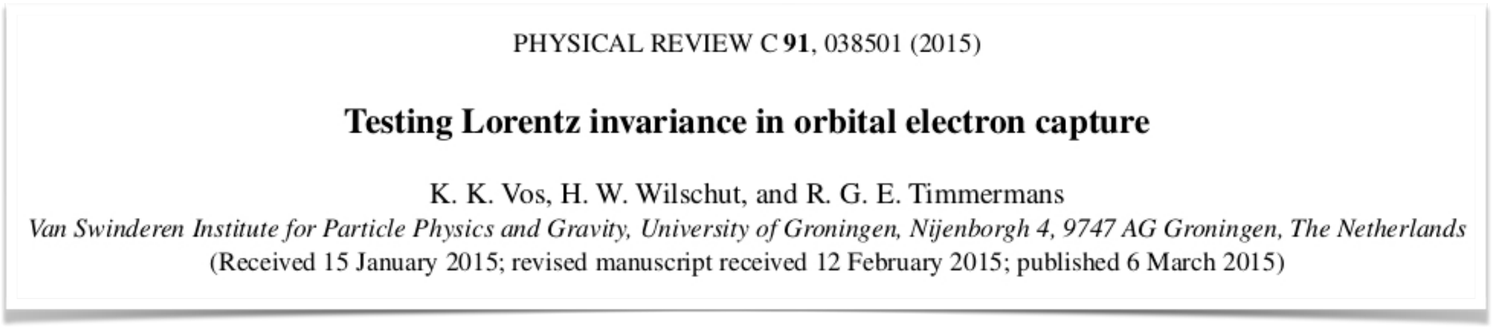
Published: *December 31, 2014*

On the particle spectrum and the conformal window

M.P. Lombardo,[a] K. Miura,[b] T.J. Nunes da Silva[c] and E. Pallante[c,1]



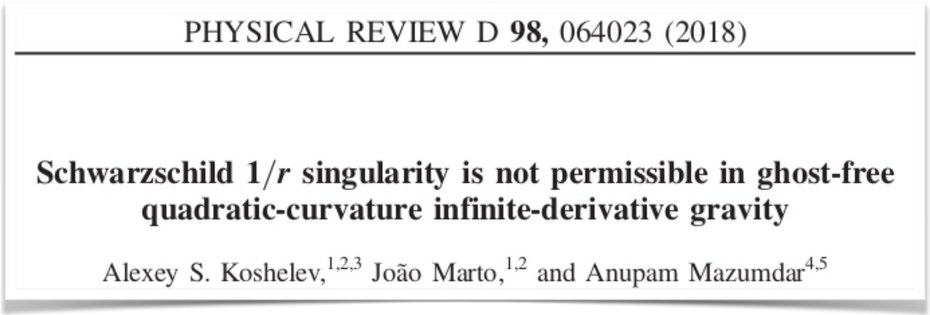
PHYSICAL REVIEW C **91**, 038501 (2015)

Testing Lorentz invariance in orbital electron capture

K. K. Vos, H. W. Wilschut, and R. G. E. Timmermans

Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands

(Received 15 January 2015; revised manuscript received 12 February 2015; published 6 March 2015)



PHYSICAL REVIEW D **98,** 064023 (2018)

Schwarzschild $1/r$ singularity is not permissible in ghost-free quadratic-curvature infinite-derivative gravity

Alexey S. Koshelev,[1,2,3] João Marto,[1,2] and Anupam Mazumdar[4,5]

RIJKSUNIVERSITEIT GRONINGEN

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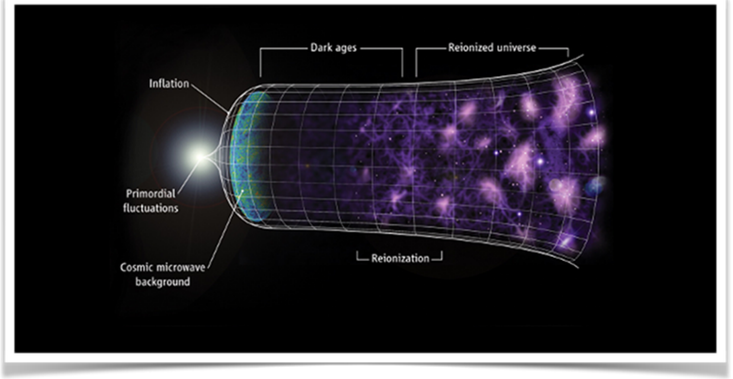
String Theory and Cosmology

- Eric Bergshoeff:
  - String theory
  - Quantum gravity
- Kyriakos Papadodimas (left 2018):
  - Black holes and quantum mechanics
- Diederik Roest:
  - String cosmology
  - Inflation
  - Supersymmetry



(FOM) Programme: A String Theoretic Approach to Cosmology and Quantum Matter

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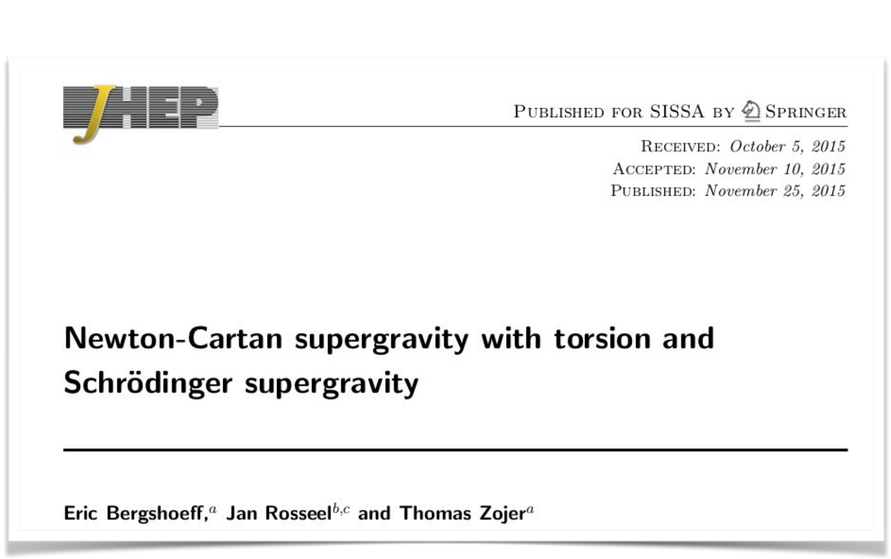
Strings & Cosmology: selection of research highlights



JHEP

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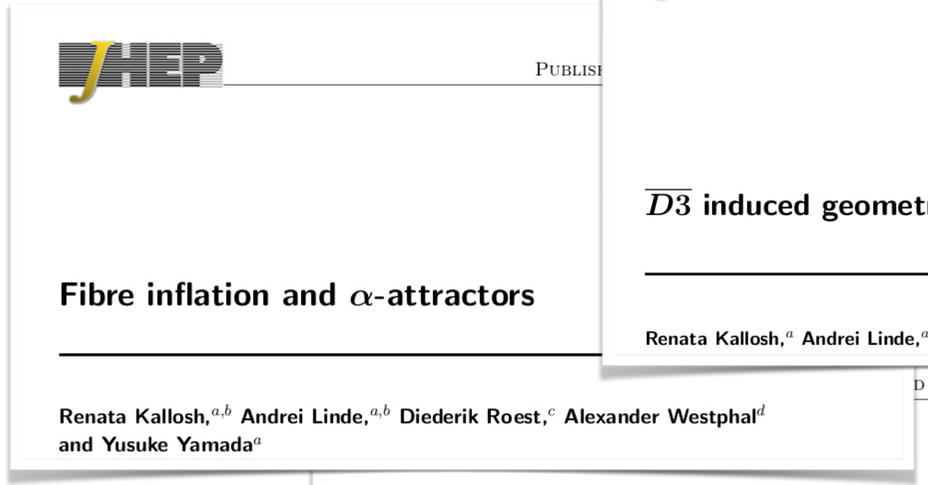
Published: November 25, 2015

Newton-Cartan supergravity with torsion and Schrödinger supergravity

Eric Bergshoeff,[a] Jan Rosseel[b,c] and Thomas Zojer[a]

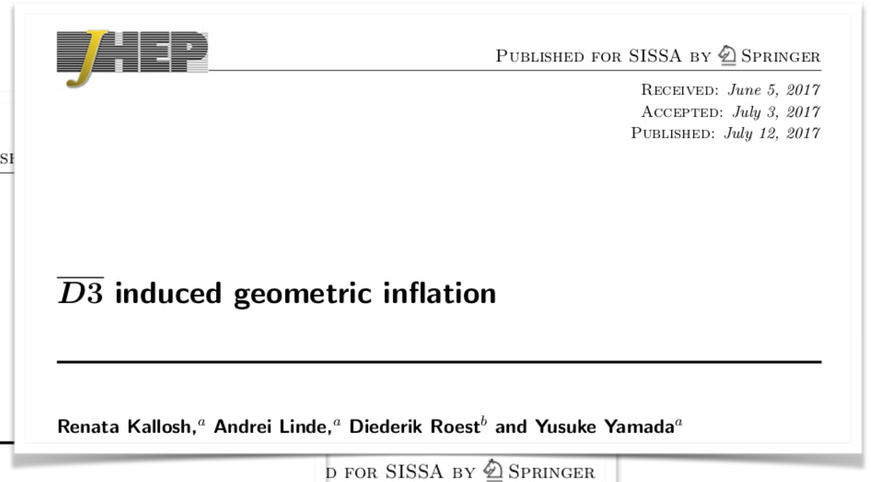


JHEP

Publis

Fibre inflation and α-attractors

Renata Kallosh,[a,b] Andrei Linde,[a,b] Diederik Roest,[c] Alexander Westphal[d] and Yusuke Yamada[a]



JHEP

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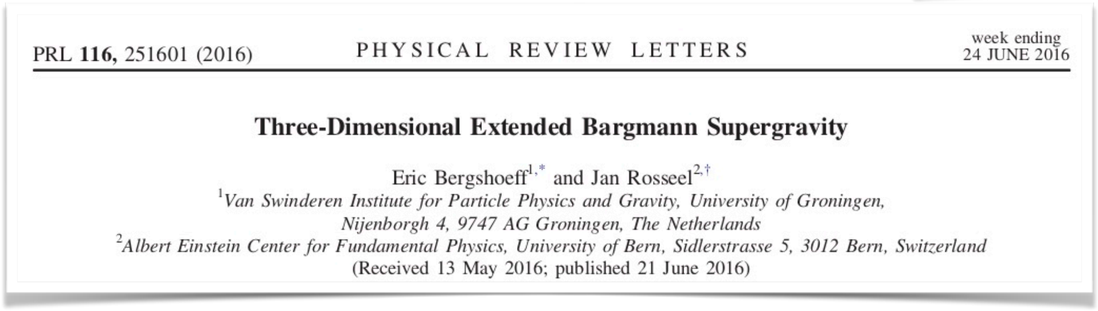
Published: July 12, 2017

$\overline{D3}$ induced geometric inflation

Renata Kallosh,[a] Andrei Linde,[a] Diederik Roest[b] and Yusuke Yamada[a]



PRL **116,** 251601 (2016) PHYSICAL REVIEW LETTERS week ending 24 JUNE 2016

Three-Dimensional Extended Bargmann Supergravity

Eric Bergshoeff[1,*] and Jan Rosseel[2,†]

[1]*Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands*

[2]*Albert Einstein Center for Fundamental Physics, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland*

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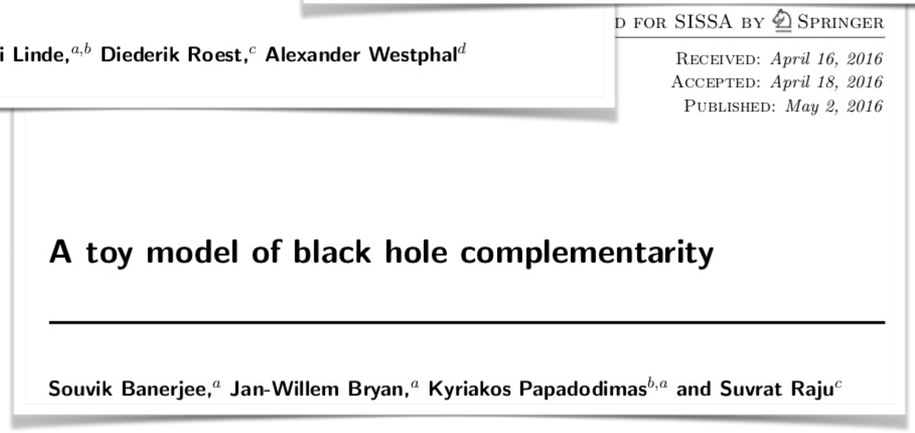

D for SISSA by Springer

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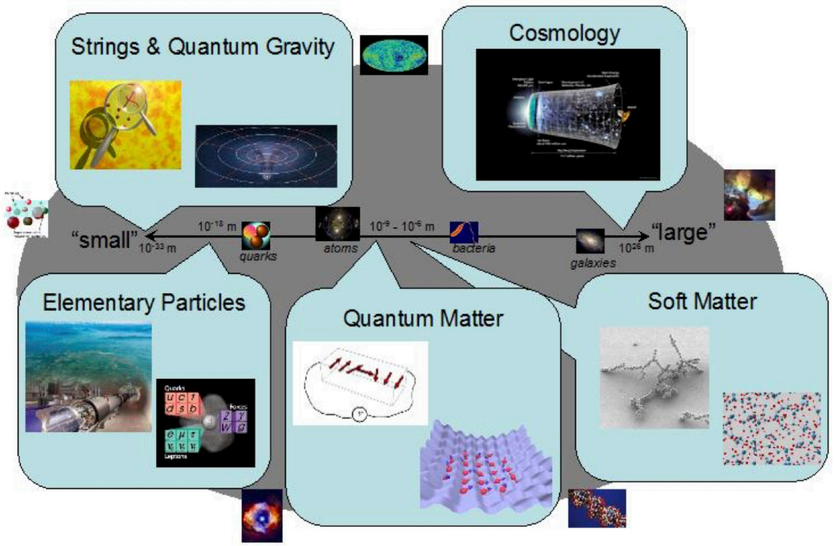
Published: May 2, 2016

A toy model of black hole complementarity

Souvik Banerjee,[a] Jan-Willem Bryan,[a] Kyriakos Papadodimas[b,a] and Suvrat Raju[c]

UNIVERSITEIT UTRECHT

- Stefan Vandoren:
  - String theory, SUSY, black holes
- Tomislav Prokopec:
  - Cosmic inflation, matter-antimatter asymmetry, dark energy
- Thomas Grimm:
  - String theory and phenomenology
- Enrico Pajer (left 2018):
  - Theoretical cosmology



UNIVERSITEIT UTRECHT

Selection of Research Highlights:

JHEP

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Published: *January 4, 2016*

F-Theory, spinning black holes and multi-string branches

Babak Haghighat,[a,b] **Sameer Murthy,**[c] **Cumrun Vafa**[a] **and Stefan Vandoren**[d]

JHEP

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Published: *August 22, 2018*

Infinite distances in field space and massless towers of states

Thomas W. Grimm,[a] **Eran Palti**[b] **and Irene Valenzuela**[a]

ELSEVIER

Physics of the Dark Universe
Volume 18, December 2017, Pages 6-10

On primordial black holes from an inflection point

Cristiano Germani [a], Tomislav Prokopec [b]

PHYSICAL REVIEW D **97,** 063531 (2018)

Editors' Suggestion

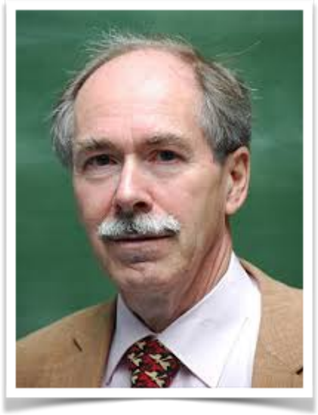
Soft theorems for shift-symmetric cosmologies

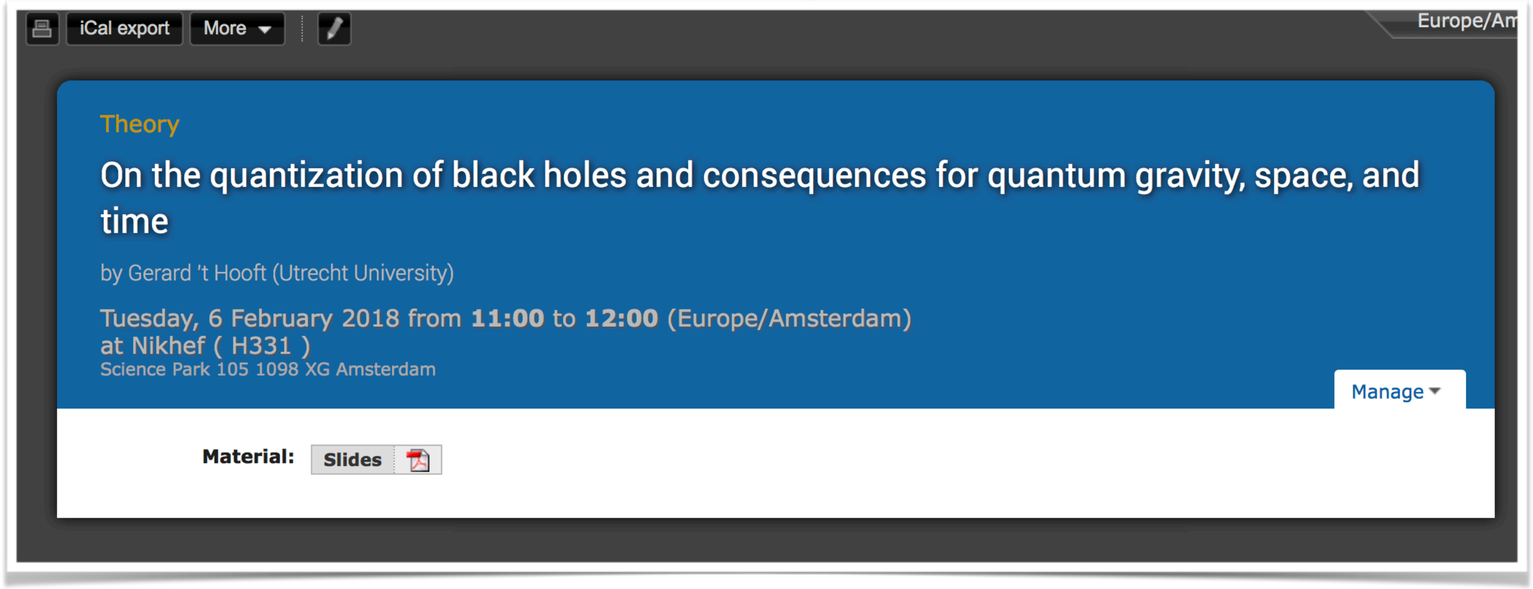
Bernardo Finelli, Garrett Goon, Enrico Pajer, and Luca Santoni
Institute for Theoretical Physics and Center for Extreme Matter and Emergent Phenomena, Utrecht University, Leuvenlaan 4, 3584 CE Utrecht, Netherlands

(Received 20 December 2017; published 30 March 2018)

UNIVERSITEIT UTRECHT

- Gerard ’t Hooft:
  - Nobel Laureate
  - Inspiring, especially to students
  - Joint Nikhef-UvA seminar (2018):





UNIVERSITEIT LEIDEN

- Ana Achúcarro:
  - Cosmology, inflation, string theory
- Alessandra Silvestri:
  - Cosmology, gravity, dark energy
- Koenraad Schalm:
  - String theory and connections to particle physics and cosmology, black holes
- Alexey Boyarsky:
  - Neutrino Minimal SM, dark matter, SHiP

+ AdS-CFT relations quantum matter: Jan Zaanen

UNIVERSITEIT LEIDEN

Selection of Research Highlights:

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Journal of Cosmology and Astroparticle Physics

Universality of multi-field α-attractors

Ana Achúcarro[a,b], Renata Kallosh[c], Andrei Linde[c], Dong-Gang Wang[a,d] and Yvette Welling[a,d]

Published 9 April 2018 • © 2018 IOP Publishing Ltd and Sissa Medialab
Journal of Cosmology and Astroparticle Physics, Volume 2018, April 2018

Phenomenology of GeV-scale Heavy Neutral Leptons

Kyrylo Bondarenko,[1] Alexey Boyarsky,[1] Dmitry Gorbunov,[2,3] Oleg Ruchayskiy[4]

PHYSICAL REVIEW D **90,** 023511 (2014)

Inflation with moderately sharp features in the speed of sound: Generalized slow roll and in-in formalism for power spectrum and bispectrum

Ana Achúcarro,[1,2,*] Vicente Atal,[1,†] Bin Hu,[1,‡] Pablo Ortiz,[1,3,§] and Jesús Torrado[1,¶]
[1]*Instituut-Lorentz for Theoretical Physics, Universiteit Leiden, 2333 CA Leiden, Netherlands*
[2]*Department of Theoretical Physics, University of the Basque Country, 48080 Bilbao, Spain*
[3]*Nikhef, Science Park 105, 1098 XG Amsterdam, Netherlands*
(Received 14 May 2014; published 8 July 2014)

PHYSICAL REVIEW D **97,** 063518 (2018)

Do current cosmological observations rule out all covariant Galileons?

Simone Peirone,[1] Noemi Frusciante,[2] Bin Hu,[3] Marco Raveri,[4,1] and Alessandra Silvestri[1]

PHYSICAL REVIEW LETTERS **120,** 231601 (2018)

Black Hole Scrambling from Hydrodynamics

Sašo Grozdanov,[1,2] Koenraad Schalm,[2] and Vincenzo Scopelliti[2]
[1]*Center for Theoretical Physics, MIT, Cambridge, Massachusetts 02139, USA*
[2]*Instituut-Lorentz for Theoretical Physics ΔITP, Leiden University, Niels Bohrweg 2, Leiden 2333 CA, The Netherlands*

(Received 14 October 2017; revised manuscript received 15 March 2018; published 7 June 2018)

PHYSICAL REVIEW B **89**, 245116 (2014)

Holographic duality and the resistivity of strange metals

Richard A. Davison,[1,*] Koenraad Schalm,[1,2,†] and Jan Zaanen[1,‡]
[1]*Instituut-Lorentz for Theoretical Physics, Universiteit Leiden, P.O. Box 9506, 2300 RA Leiden, The Netherlands*
[2]*Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA*
(Received 12 November 2013; revised manuscript received 17 May 2014; published 12 June 2014)

UNIVERSITEIT LEIDEN

Focus on Cosmology:

(FOM) Programme:

“Observing the Big Bang”

cosmology.nl

+ Links to (String)-Cosmology in Utrecht, Groningen and Amsterdam

UNIVERSITEIT VAN AMSTERDAM

Institute for Theoretical Physics Amsterdam (ITFA)

- Jan de Boer:
  - String theory
- Daniel Baumann:
  - Strings, cosmology

- Alejandra Castro:
  - String theory

- Miranda Cheng:
  - Mathematical physics

- Ben Freivogel:
  - Strings, cosmology

- Diego Hofman:
  - String theory

- Jan Pieter van der Schaar:
  - Cosmology

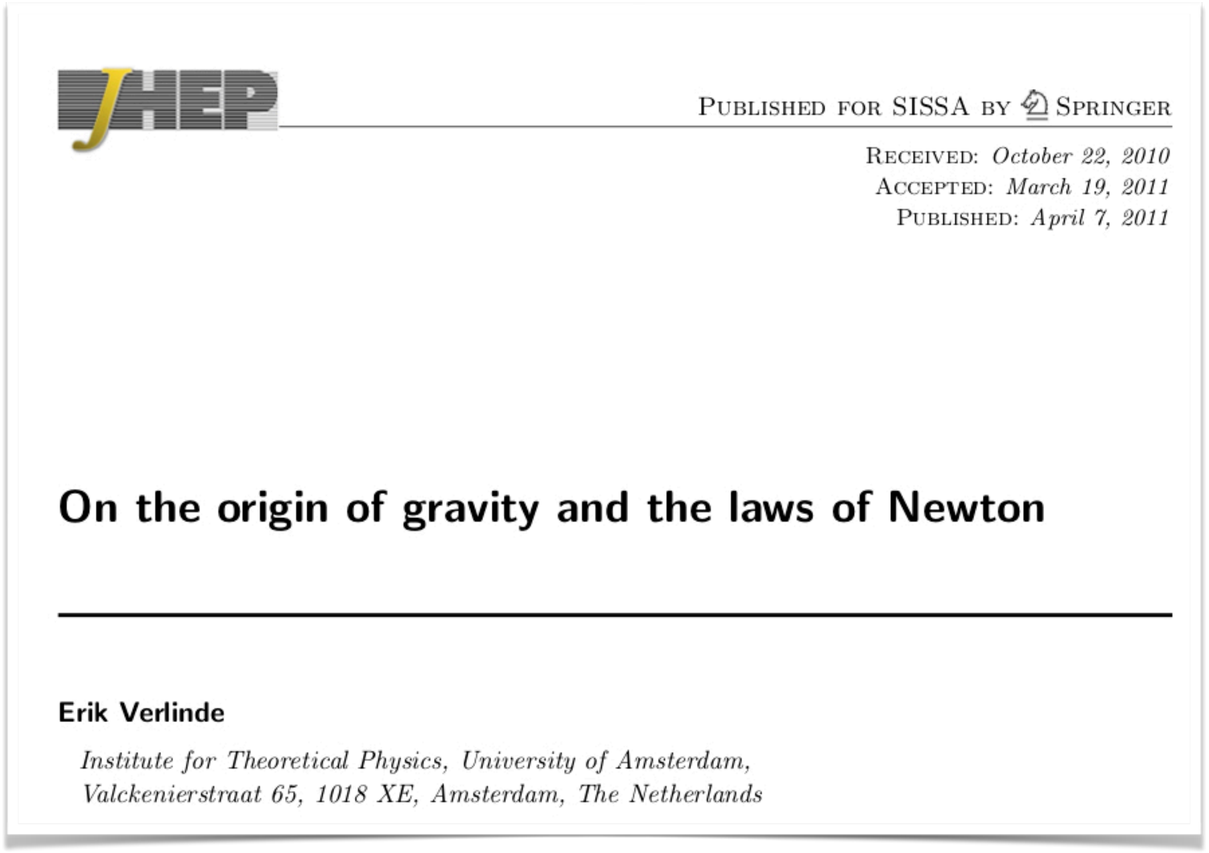
- Erik Verlinde:
  - String theory, emergent gravity

- Eric Laenen:
  - Collider physics, Higgs, QCD

- Wouter Waalewijn:
  - QCD, SCET

UNIVERSITEIT VAN AMSTERDAM

ITFA: some research highlights



JHEP

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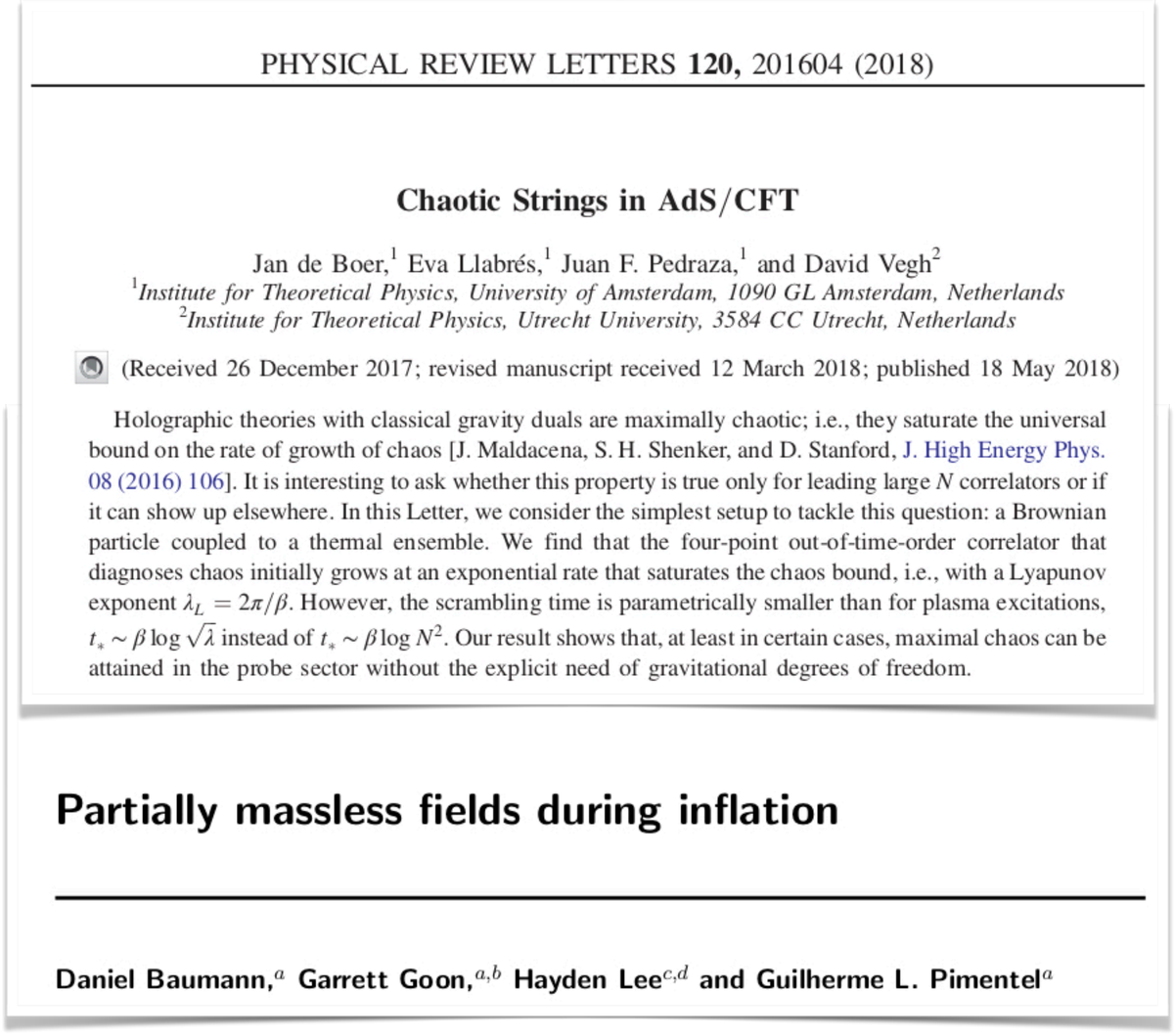
ACCEPTED: *March 19, 2011*
PUBLISHED: *April 7, 2011*

On the origin of gravity and the laws of Newton

Erik Verlinde

Institute for Theoretical Physics, University of Amsterdam, Valckenierstraat 65, 1018 XE, Amsterdam, The Netherlands



PHYSICAL REVIEW LETTERS **120,** 201604 (2018)

Chaotic Strings in AdS/CFT

Jan de Boer,[1] Eva Llabrés,[1] Juan F. Pedraza,[1] and David Vegh[2]
[1]*Institute for Theoretical Physics, University of Amsterdam, 1090 GL Amsterdam, Netherlands*
[2]*Institute for Theoretical Physics, Utrecht University, 3584 CC Utrecht, Netherlands*

(Received 26 December 2017; revised manuscript received 12 March 2018; published 18 May 2018)

Holographic theories with classical gravity duals are maximally chaotic; i.e., they saturate the universal bound on the rate of growth of chaos [J. Maldacena, S. H. Shenker, and D. Stanford, J. High Energy Phys. 08 (2016) 106]. It is interesting to ask whether this property is true only for leading large N correlators or if it can show up elsewhere. In this Letter, we consider the simplest setup to tackle this question: a Brownian particle coupled to a thermal ensemble. We find that the four-point out-of-time-order correlator that diagnoses chaos initially grows at an exponential rate that saturates the chaos bound, i.e., with a Lyapunov exponent $\lambda_L = 2\pi/\beta$. However, the scrambling time is parametrically smaller than for plasma excitations, $t_* \sim \beta \log \sqrt{\lambda}$ instead of $t_* \sim \beta \log N^2$. Our result shows that, at least in certain cases, maximal chaos can be attained in the probe sector without the explicit need of gravitational degrees of freedom.

Partially massless fields during inflation

Daniel Baumann,[a] Garrett Goon,[a,b] Hayden Lee[c,d] and Guilherme L. Pimentel[a]

UNIVERSITEIT VAN AMSTERDAM

Gravitation AstroParticle Physics Amsterdam

- Gianfranco Bertone:
  - Dark matter

- Shin'ichiro Ando:
  - Strings, cosmology

- Samaya Nissanke (+2018):
  - Gravitational waves

- Christoph Weniger:
  - Dark matter, GAMBIT

- Sera Markoff:
  - Accretion around black holes

- Selma de Mink:
  - Evolution of stars, binary systems

- Jacco Vink:
  - High energy astrophysics

[Astrophysicists]

+ Daniel Baumann, Ben Freivogel

+ Experiment: Patrick Decowski

UNIVERSITEIT VAN AMSTERDAM

GRAPPA: selection of research highlights

REVIEW

https://doi.org/10.1038/s41586-018-0542-z

A new era in the search for dark matter

Gianfranco Bertone[1]* & Tim M. P. Tait[1,2]*

There is a growing sense of 'crisis' in the dark-matter particle community, which arises from the absence of evidence for the most popular candidates for dark-matter particles—such as weakly interacting massive particles, axions and sterile neutrinos—despite the enormous effort that has gone into searching for these particles. Here we discuss what we have learned about the nature of dark matter from past experiments and the implications for planned dark-matter searches in the next decade. We argue that diversifying the experimental effort and incorporating astronomical surveys and gravitational-wave observations is our best hope of making progress on the dark-matter problem.

PHYSICAL REVIEW D **98,** 023536 (2018)

Merger rate of a subdominant population of primordial black holes

Bradley J. Kavanagh, Daniele Gaggero, and Gianfranco Bertone
Gravitation Astroparticle Physics Amsterdam (GRAPPA), Institute for Theoretical Physics Amsterdam and Delta Institute for Theoretical Physics, University of Amsterdam, Science Park 904, 1090 GL Amsterdam, Netherlands

(Received 30 May 2018; published 25 July 2018)

The formation of astrophysical and primordial black holes influences the distribution of dark matter surrounding them. Black holes are thus expected to carry a dark matter "dress" whose properties depend on their formation mechanism and on the properties of the environment. Here we carry out a numerical and analytical study of the merger of dressed black holes, and show that the distribution of dark matter around them dramatically affects the dynamical evolution of the binaries. Although the final impact on the merger rate of primordial black holes is rather small with respect to the case of "naked" black holes, we argue that our analysis places the calculation of this rate on more solid ground, with LIGO-Virgo observations ruling out a dark matter fraction of 10^{-3} for primordial black holes of 100 solar masses, and it paves the way to more detailed analyses of environmental effects induced by dark matter on the gravitational wave emission of binary black holes.

Eur. Phys. J. C (2017) 77:831
https://doi.org/10.1140/epjc/s10052-017-5155-4

THE EUROPEAN PHYSICAL JOURNAL C

CrossMark

Regular Article - Theoretical Physics

DarkBit: a GAMBIT module for computing dark matter observables and likelihoods

The GAMBIT Dark Matter Workgroup: Torsten Bringmann[1,a], Jan Conrad[2,3], Jonathan M. Cornell[4,b], Lars A. Dal[1], Joakim Edsjö[2,3], Ben Farmer[2,3], Felix Kahlhoefer[5], Anders Kvellestad[6], Antje Putze[7], Christopher Savage[6], Pat Scott[8,c], Christoph Weniger[9,d], Martin White[10,11], Sebastian Wild[5]

PRL **115,** 071301 (2015) PHYSICAL REVIEW LETTERS week ending 14 AUGUST 2015

Testing the Dark Matter Scenario for PeV Neutrinos Observed in IceCube

Kohta Murase,[1,2] Ranjan Laha,[3] Shin'ichiro Ando,[4] and Markus Ahlers[5]

EDUCATION IN THEORETICAL PHYSICS

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  - Quantum matter + information, condensed matter, biophysics
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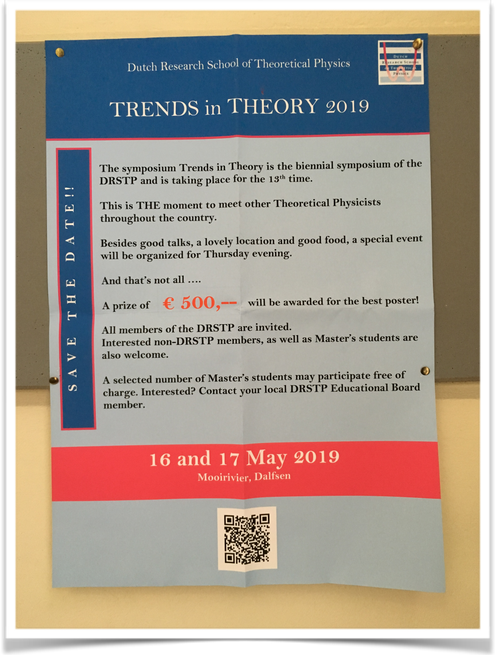
  - PhD day organised by the students
- National Seminar Theoretical High Energy Physics
- Biennial symposium: TRENDS in THEORY

https://web.science.uu.nl/drstp/



IMPRESSIONS TRENDS IN THEORY 2017

Dutch Research School of Theoretical Physics

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[Links](#)
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SYMPOSIUM TRENDS IN THEORY 2017

12th biennial symposium of the Dutch Research School of Theoretical Physics

The symposium is organized to give an overview of research activities in theoretical physics in the Netherlands. We look forward to welcoming all members of the DRSTP on this occasion.

Date: Thursday 11 + Friday 12 May 2017

Target group: Interested non-DRSTP members, as well as Master's students, are also invited to attend; the only limitation is the capacity of the accommodation at the hotel.
A selected number of Master's students may participate free of charge. Interested? Please contact your local member of the DRSTP Educational Board.

Language: English

Lecturers and abstracts:

Alejandra Castro [UvA]: *New insights into extremal black holes*

Jasper van Wezel [UvA]: *Topological classification of crystalline insulators through band structure combinatorics*

Carmine Ortix [UU]: *Fermi arcs and Dirac cones in time-reversal invariant Weyl semimetals*

Juan Rojo [VUA]: *Artificial neural networks, the proton structure, and Higgs physics at the LHC*

Kareljan Schoutens [UvA]: *Quantum control and quantum algorithms*

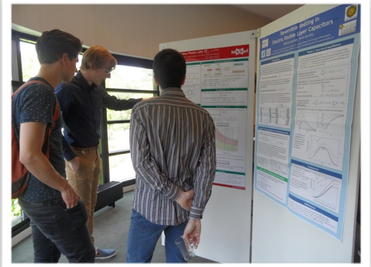
Alessandra Silvestri [UL]: *Unveiling dark energy from the large scale structure: the theoretical side of the challenge*

Paul Tiesinga [RU Donders Institute]: *Networks of cognition*

Chris Van den Broek [Nikhef]: *Gravitational waves: the interplay between theory and observations*

Evening lecturer - Ionica Smeets (UL): *Science communication for physicists*

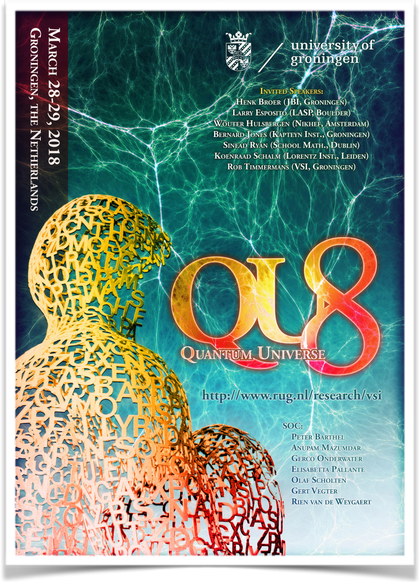




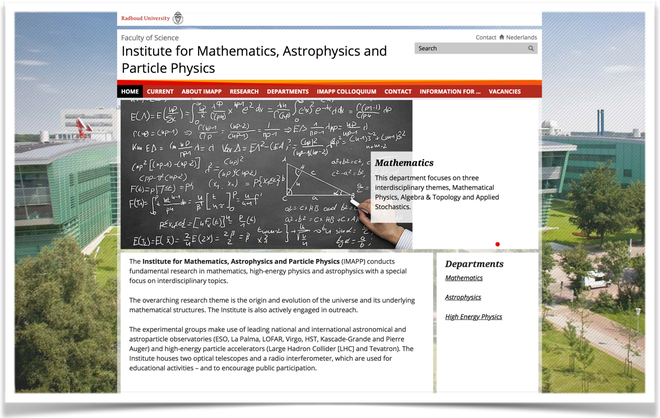
http://web.science.uu.nl/DRSTP/Conferences/Trends/2017/info.html

THEORY INITIATIVES

Bringing people together:



- Phenomenology meetings @ Nikhef:
  - Once per month in an informal setting with presentations
- Cosmology meetings and network centred @ Leiden:
  - cosmology.nl
- Quantum Universe @ Groningen University:
  - Initiative with Symposium once a year
- IMAPP @ Radboud University Nijmegen:
  - Institute for Mathematics, Astrophysics and Particle Physics
- GRAPPA @ University of Amsterdam:
  - Centre of excellence for Gravitation and Astroparticle Physics



GRAPPA
GRavitation AstroParticle Physics Amsterdam

HIGH-ENERGY THEORY NETWORK

- Long-standing, semi-formal network of all (about 45) Hth permanent staff members in the Netherlands, connecting Phenomenology, Cosmology and String Theory.
- We have two meetings per year to discuss common issues, such as DRSTP schools and funding initiatives, and to provide information exchange.
- Supported by (FOM) NWO: an official is always present and helpful!
- Now a formal advisory body for the NWO Physics Table via 3 members [Achúcarro, Bergshoeff, Laenen] in Particle and Astroparticle Physics (PAPP) Advisory Committee [+ 7 exp. members]:
  - The task of the PAPP is to advise the Physis Table and the ENW-domain board, monitoring the progress in the various research programmes.
  - This is all quite new, and we have to see how it will work out…

THEORETICAL PARTICLE PHYSICS FUNDING

- "Sectorplan" funding: [2010]
  - Astroparticle physics highlight: GRAPPA
- NWO "Zwaartekracht" grant: [2012-22]
  - Delta ITP Institute: 18.3 M€
- FOM Programmes: up to about 2.5 M€
  - Particle Physics Phenomenology
  - Theoretical Cosmology
  - String Theory; Quantum Gravity
  - Dark Matter (experiment + theory)
- Individual grants: (0.5-2.5) M€
  - "Projectruimte"; NWO Veni, Vidi, Vici; ERC, …

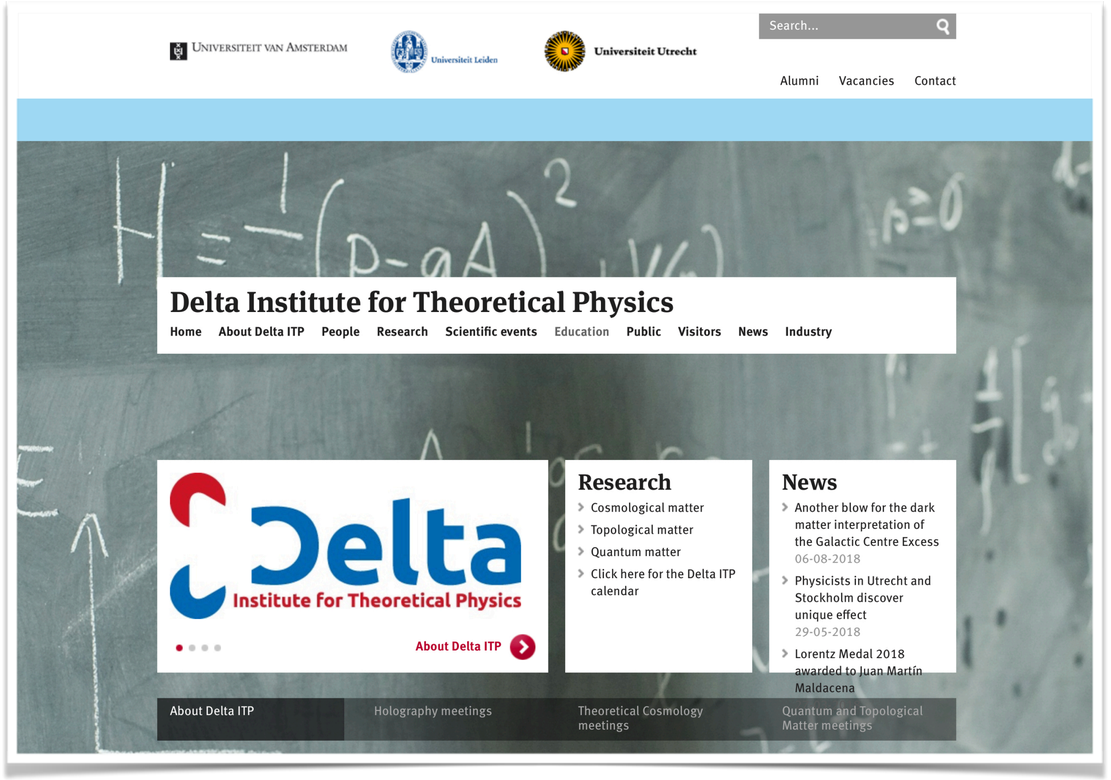
Key funding for postdocs and PhD students

DELTA INSTITUTE FOR THEORETICAL PHYSICS

- Delta ITP: [18.3 M€ for 10 years]

Virtual Institute from UvA, UL, UU:

- 6 tenure track positions
- Special postdoc and PhD positions
- Visitor programme
- Seminars and meetings
- Lecture programmes
- +…



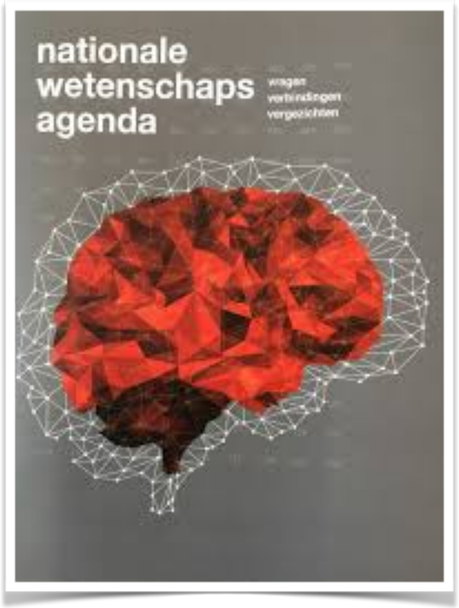
→ *Very successful initiative!*

FUNDING OPPORTUNITIES

- New “Sectorplan” is under construction:
  - Seven topics, including theoretical physics
- Dutch National Research Agenda: 25 Routes

  Route 2: Building blocks of matter and fundaments of space and time

  - Einstein Telescope
  - Dutch Institute for Emergent Phenomena (DIEP)
- NWO funding instruments: competition (?)
  - KLEIN [FOM Projectruimtes], GROOT [FOM Programmes]
- ERC + vacancies opening up



NWO
Netherlands Organisation for Scientific Research

OUTLOOK

- Theory Group @ Nikhef:
  - Further expand role as national phenomenology centre
  - Maintain strong links with the experimental groups
  - Explore synergies with UvA/GRAPPA in astroparticle physics
  - Further exploit opportunities from gravitational waves
  - Secure the future of FORM
- Dutch theory community:
  - Maintain excellence in research
  - Continue to attract talent and bring it quickly to the forefront of research
  - Maintain success in funding (how will the new NWO instruments work?)
  - Keep fruitful links with the CERN theory group

CONCERNS

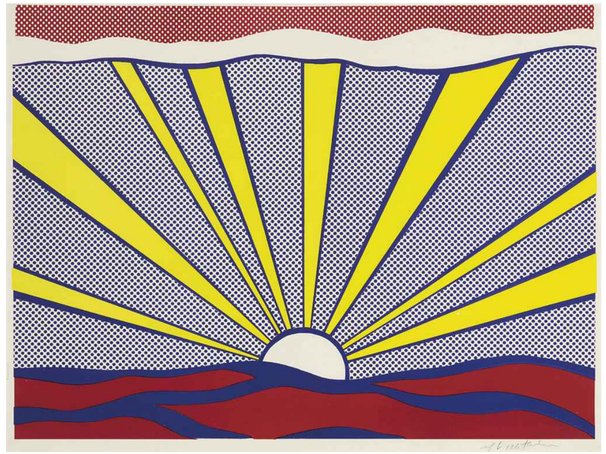
- Constraints for funding sometimes challenging for theory:
  - Practical applications (“valorisation”).
  - Requirements to have an involvement of industry.

- Grant proposals:
  - It takes a lot of time to *write* proposals and use new funding instruments.
  - It takes a lot of time to *review/referee* proposals.
  - Competition with other fields: how to compare excellence?

FINAL PERSONAL COMMENTS

- I have moved to Nikhef about 9 years ago from CERN Theory.
- I'm still very impressed by the diversity of the theoretical physics landscape and Nikhef as the National Centre for Particle Physics.
- Lots of interactions among people.
- Excellent access to students through Universities.

Looking forward to the years ahead!



[R. Lichtenstein, Sunrise (1965)]