PROJECTIONS

ASYMPTOTIC SAFETY IN A DARK UNIVERSE

**PERIMETER INSTITUTE
WATERLOO, ON, CANADA**

JUNE 5-7, 2018

KAĆA BRADONJIĆ

TABLE OF CONTENTS

PROJECTIONS

An academic talk and the subsequent discussion is a public display of an otherwise mostly closed-door affair, and it exposes the complex nature of the creation of knowledge. *Projections* is a series of artworks aiming to give visual representation to academic talks, mostly on the topics of physics and philosophy of physics. In a way, each *Projection* is a field report of my experience of a talk, which itself is a multidimensional beast existing in a space that exceeds the four-dimensional confines of a conference room. The talk is diffracted by my own sensibilities and projected onto the paper in real time. Some pieces are the projections of the abstract conceptual world of our models of reality and their symbolic representations: String, Loop, Set; Zero, Asymptotic, Infinity; State, Superposition, Entanglement. Others capture the emotional and the social dimensions of the talk: Enthusiasm, Self-doubt, Bravado; Camaraderie, Conflict, Agreement; Confusion, Insight, Understanding. Most of the *Projections*, however, are half-profiles: Confinement, Freedom, Exclusion; Interaction, Interference, Perturbation; Uncertainty, Confidence, Safety.

CONFERENCE INFORMATION

Asymptotic Safety in a Dark Universe

Perimeter Institute
Waterloo, ON, Canada
June 5-7, 2018

The asymptotic safety paradigm is currently emerging as a highly promising idea for Beyond-Standard-Model physics with key progress in asymptotically safe quantum gravity and asymptotically safe matter models. The last years have seen not only the development of asymptotically safe gravity-matter models but also the discovery of asymptotically safe beyond Standard Model matter models that are under control in perturbation theory. New exciting avenues in (astro) particle physics are now waiting to be explored. For example although the nature of dark matter is a long-standing riddle it is a fact that experimental searches have so far not provided any direct clues but have instead come up with ever more stringent constraints on theoretically preferred regions of parameter space for dark-matter-models. Thus the key to unraveling this riddle could be a new theoretical paradigm to guide model builders. This workshop aims at exploring whether asymptotic safety can be a candidate for this new paradigm. We aim to bring together experts on phenomenological models and quantum gravity to probe both the theoretical viability and empirical signatures of asymptotically safe extensions of the standard model that include gravity. To facilitate a highly productive meeting that can trigger new collaborations each talk will be followed up by 15-20 minutes discussion time. Further each day of the workshop will feature a dedicated discussion session. Participants will be encouraged to contribute questions for the discussion both before as well as during the workshop. The last day of the workshop will conclude with a roadmap discussion during which all participants will be given the opportunity to propose concrete suggestions for follow-up work that might lead into future joint projects.

Conference Website: https://pirsa.org/C18012

JUNE 5, 2018

FRANCESCO SANNINO, "CHARTING FUNDAMENTAL INTERACTIONS", 1

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 5, 2018

Abstract: I summarise the state-of-the-art in our understanding of fundamental interactions and will set the stage for present and future studies and phenomenological applications.

Video recording: https://pirsa.org/18060009

FRANCESCO SANNINO, "CHARTING FUNDAMENTAL INTERACTIONS", 2

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 5, 2018

Abstract: I summarise the state-of-the-art in our understanding of fundamental interactions and will set the stage for present and future studies and phenomenological applications.
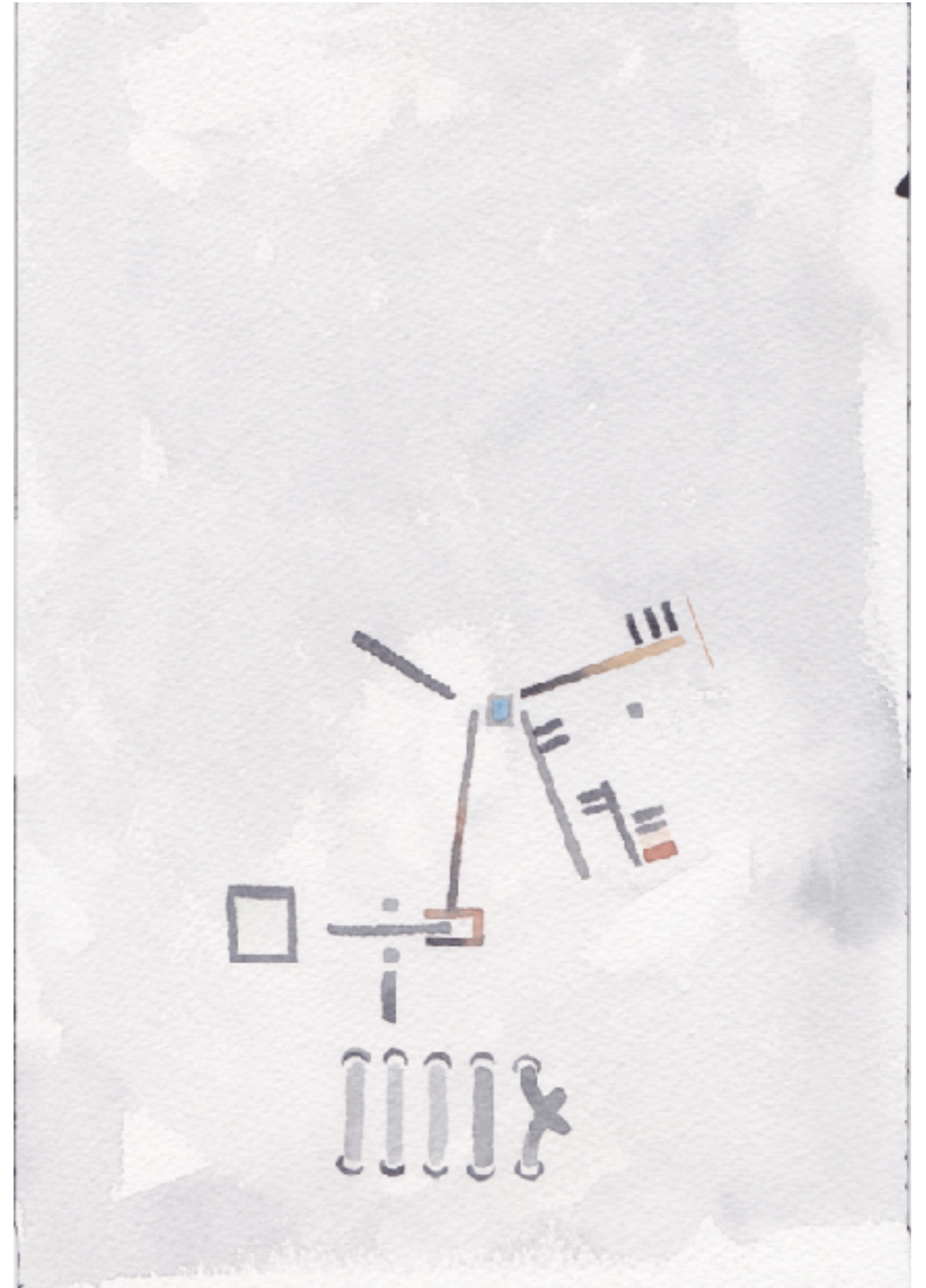
Video recording: https://pirsa.org/18060009

# DANIEL LITIM, "ASYMPTOTIC SAFETY WITH AND WITHOUT SUPERSYMMETRY"

Watercolor on paper
7 × 10 in (17.8 × 25.4 cm)
June 5, 2018

Abstract: I discuss the state of affairs for asymptotic safety in particle physics with and without supersymmetry.I discuss the state of affairs for asymptotic safety in particle physics with and without supersymmetry.

Video recording: https://pirsa.org/18060010
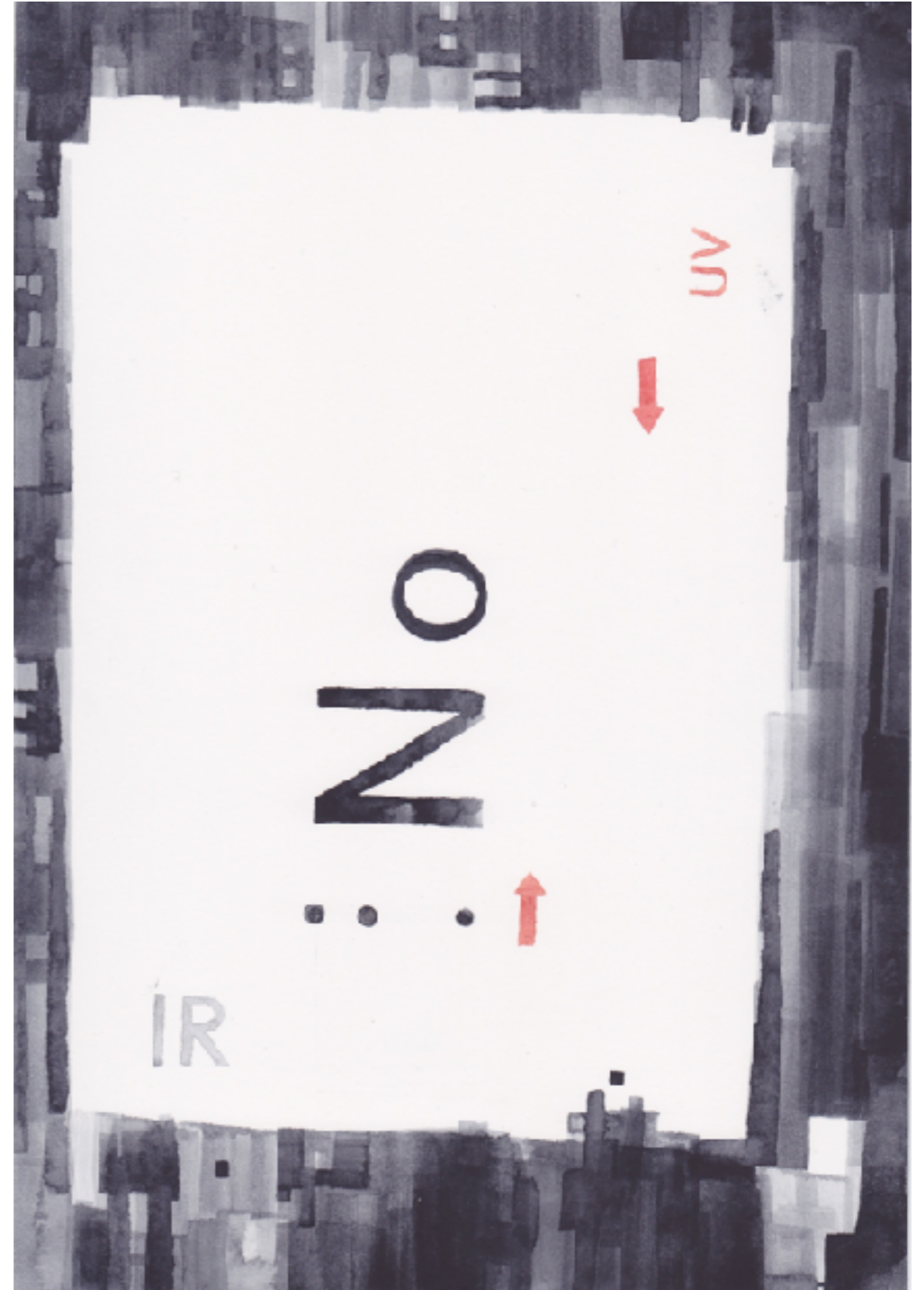
DISCUSSION 1

Watercolor on paper
10 × 14 in (25.4 × 35.6 cm)
June 5, 2018

Abstract: N/A

Video recording: https://pirsa.org/18060011

STEVEN ABEL, "PROGRESS IN CONSTRUCTING AN ASYMPTOTICALLY SAFE STANDARD MODEL", 1

Watercolor on paper
7 × 10 in (17.8 × 25.4 cm)
June 5, 2018
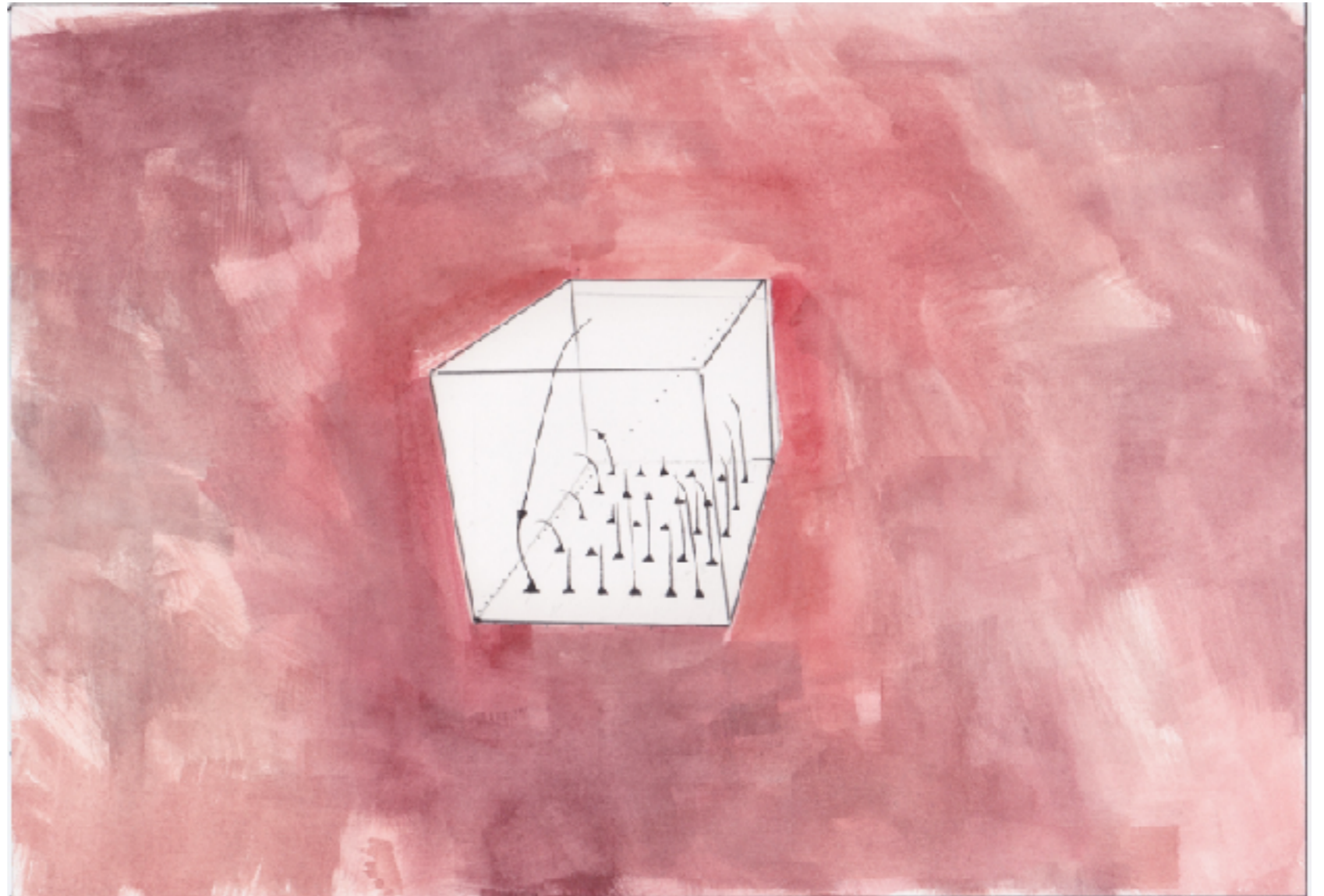
Abstract: I outline a configuration in which the Standard Model can be embedded into an asymptotically safe gauge-Yukawa theory. The model can be though of as a minimal UV completion of the SM without gravity. I also discuss the remaining issues that need to be addressed for the scheme to be phenomenologically viable, and outline the different energy scales and possible signatures.

Video recording: https://pirsa.org/18060013

STEVEN ABEL, "PROGRESS IN CONSTRUCTING AN ASYMPTOTICALLY SAFE STANDARD MODEL", 2

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 5, 2018

Abstract: I outline a configuration in which the Standard Model can be embedded into an asymptotically safe gauge-Yukawa theory. The model can be though of as a minimal UV completion of the SM without gravity. I also discuss the remaining issues that need to be addressed for the scheme to be phenomenologically viable, and outline the different energy scales and possible signatures.

Video recording: https://pirsa.org/18060013

NIAYESH AFSHORDI, "COSMOLOGICAL NON-CONSTANT PROBLEM"

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 5, 2018

Abstract: I will discuss how studying the gravitational effects of UV physics on large (astrophysical) scales precludes new mass scales in BSM physics beyond 600 GeV.

Video recording: https://pirsa.org/18060014

DISCUSSION 2

Watercolor on paper
10 × 14 in (25.4 × 35.6 cm)
June 5, 2018

Abstract: N/A

Video recording: https://pirsa.org/18060012

JUNE 6, 2018

**MANUEL REICHERT,
"ASYMPTOTIC SAFETY OF
GRAVITY-MATTER SYSTEMS
AND EFFECTIVE UNIVERSALITY"**

Watercolor on paper
7 × 10 in (17.8 × 25.4 cm)
June 6, 2018

Abstract: We review the status of asymptotically safe gravity-matter systems. The existence of a UV fixed point in such systems is guaranteed if the matter-self couplings are weak and if higher-derivative gravity terms are neglected. We show how this can manifest itself in a functional renormalisation group computation. Such gravity-matter systems contain various avatars of the dynamical Newton's coupling, e.g. gravitational self-couplings or matter-graviton couplings. We uncover an effective universality for the dynamical Newton's coupling on the quantum level: its momentum-dependent avatars are in remarkable quantitative agreement in the scaling regime of the UV fixed point. This emergence of effective universality is a strong indication for the physical nature of the UV fixed point and it provides a guiding principle for setting up future truncations.

Video recording: https://pirsa.org/18060022

ASTRID EICHHORN, "SHEDDING LIGHT ON DARK MATTER IN ASYMPTOTIC SAFETY"

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 6, 2018

Abstract: The nature of dark matter is one of the outstanding riddles of fundamental physics. Here, I will discuss first steps to explore dark matter in the asymptotic safety paradigm. As a first example, I will show indications for an asymptotically safe fixed point in the Higgs portal to fermionic dark matter, leading to a relation between the Higgs portal coupling and the dark matter mass. This model also serves as an example for different mechanisms that generate asymptotic safety. I will then review some properties of an extended Higgs sector under the coupling to asymptotically safe quantum gravity and discuss how quantum gravity fluctuations flatten the Higgs potential and thus lead to a decoupling of scalar singlets which are subject to experimental searches for dark matter.

Video recording: https://pirsa.org/18060023

ANDERS ELLER THOMSEN, "BETA FUNCTIONS AT LARGE N_F"

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 6, 2018

Abstract: Including a large number of vector-like fermions can be used to generate fixed points for the RG flows of gauge theories. Recently this has been used as a foundation for constructing UV safe models. The talk will focus on the machinery behind the large N_f computations extended to generic gauge-Yukawa theories. For semi-simple gauge theories the phase diagram shows the persistence that the UV fixed point of simple gauge theories.

Video recording: https://pirsa.org/18060025
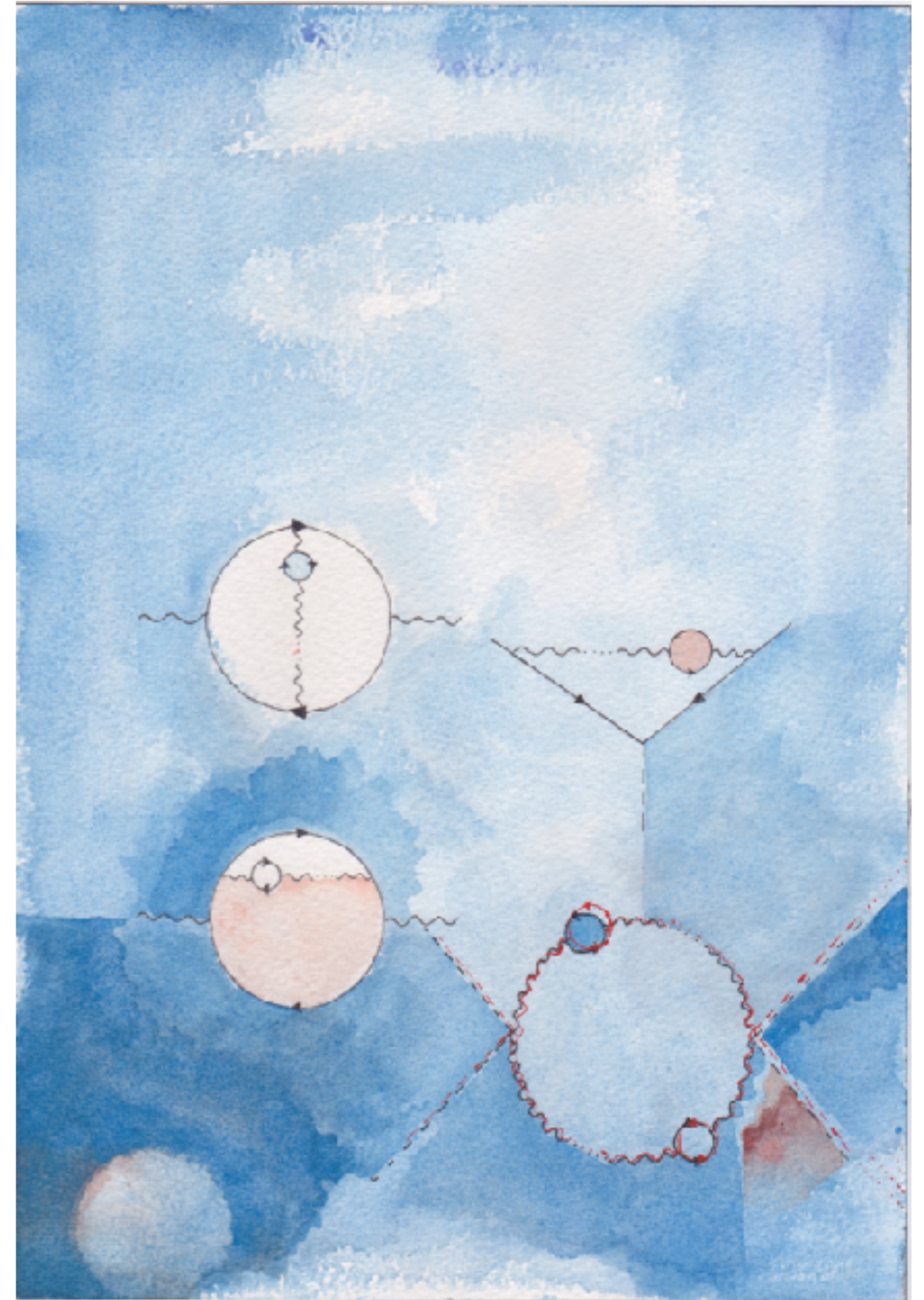
NICOLA DONDI, "CONSTRAINING ASYMPTOTIC SAFETY USING CENTRAL CHARGES"

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 6, 2018

Abstract: I will present constraints from central charges and gradient flow relations on UV and IR interacting fixed points under perturbative control. It is possible to extend this methodology beyond perturbation theory for supersymmetric theories where the central charges are calculated to all orders. In this case, these constraints draw a complex map of possible RG flows, some of them compatible with Asymptotic Safety. Examples of such SUSY theories are discussed
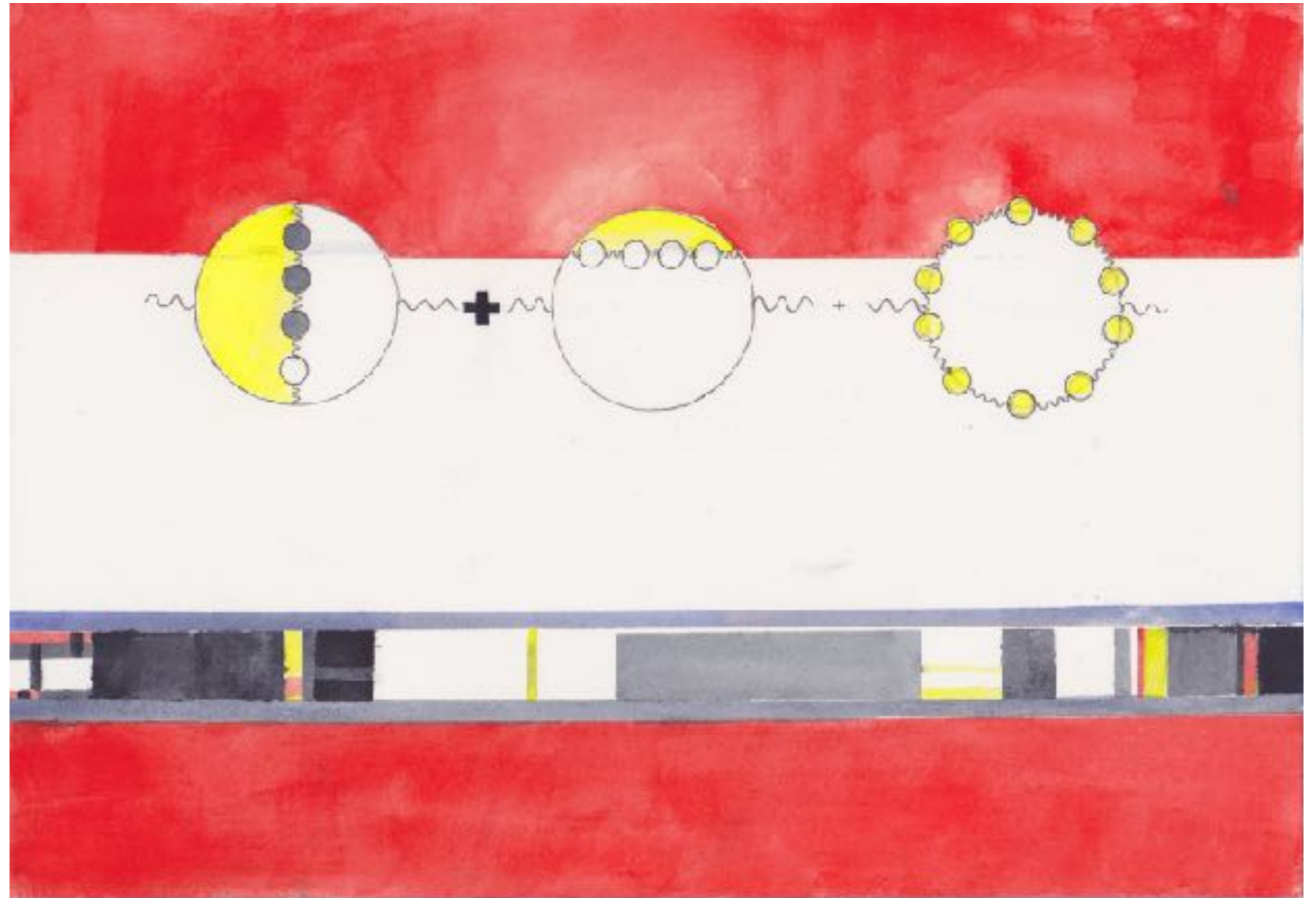
Video recording: https://pirsa.org/18060024

JUNE 7, 2018

ROBERT MANN, "KEEPING THE STANDARD MODEL SAFE" V

Watercolor on paper
7 × 10 in (17.8 × 25.4 cm)
June 7, 2018

Abstract: An increasing number of researchers are considering the possibility that the Standard Model, appropriately extended, can attain an interacting ultraviolet fixed point. Such a theory could, in the Wilsonian sense, be regarded as a fundamental theory. I will describe recent work that shows this goal is attainable in principle by adding gauged vector-like fermions to the Standard Model, in the limit of a large number of fermion fields. With this proof-of-principle demonstration, the challenge now to find realistic asymptotically safe extensions of the Standard Model with interesting and falsifiable phenomenological signatures.

Video recording: https://pirsa.org/18060020

**ZHI-WEI WANG,
"ASYMPTOTICALLY SAFE
GRAND UNIFIED THEORIES"**

Watercolor on paper
7 × 10 in (17.8 × 25.4 cm)
June 7, 2018

Abstract: N/A

Video recording: https://pirsa.org/18060021
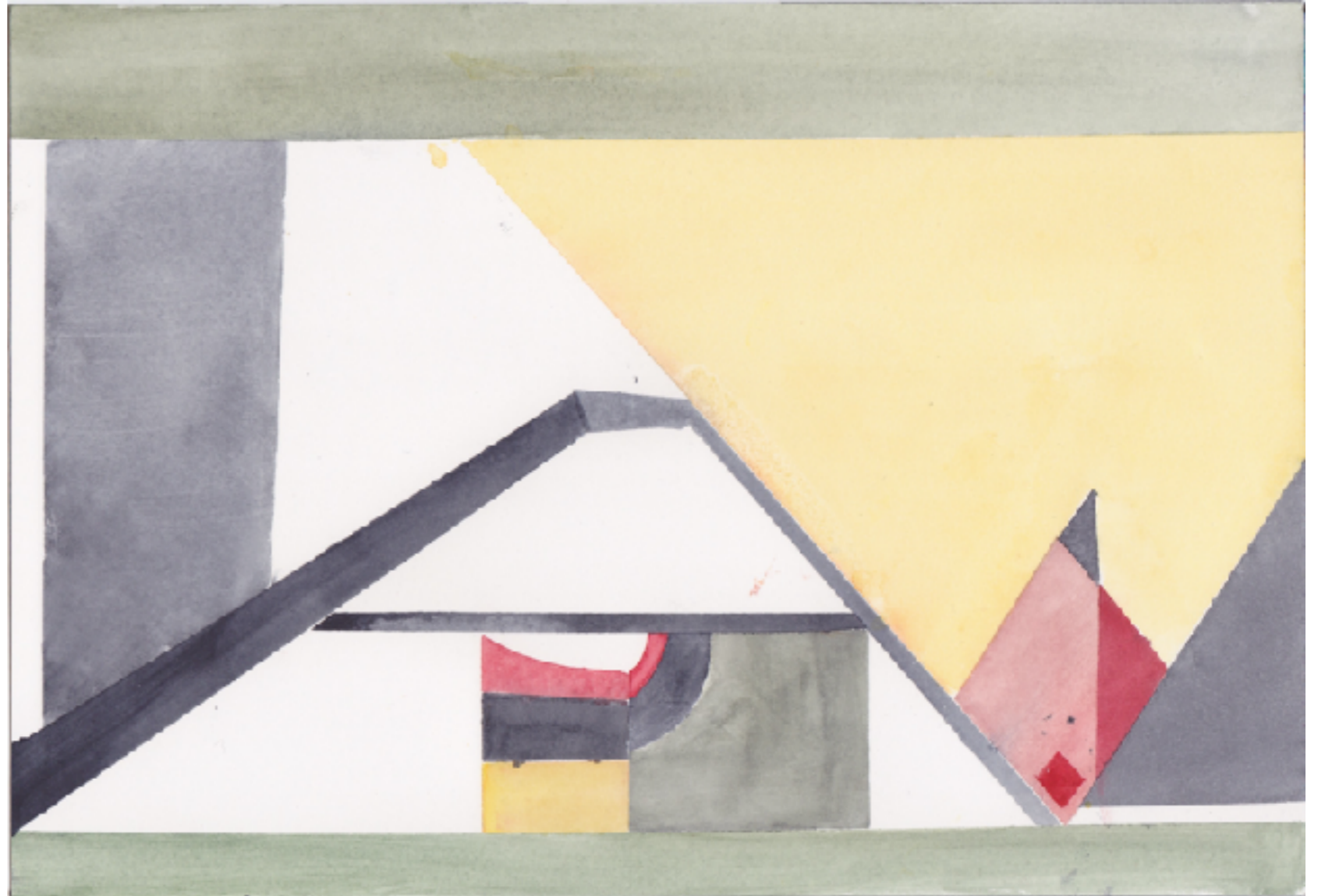
MASATOSHI YAMADA, "ASYMPTOTICALLY SAFE GRAVITY AND ELECTROWEAK SCALEGENESIS"

Watercolor on paper
10 × 7 in (25.4 × 17.8 cm)
June 7, 2018

Abstract: We discuss the impact of quantum gravity fluctuations on a scalar mass. In case that the scalar mass becomes irrelevant above the Planck scale, there could be solutions to the gauge hierarchy problem. In this talk, we consider the so-called classically scale invariant extension of the standard model, where non-abelian scalar-gauge theory in a dark sector is introduced to explain the origin of the electroweak scale. We discuss its phenomenological implications towards probing new physics.

Video recording: https://pirsa.org/18060016

THE AUTHOR

Kaća Bradonjić is a visual artist and an Assistant Professor of Physics at Hampshire College, Amherst, MA.