my presentation, considerations on neutrinos, two celebrations and more

an important birthday for astroparticle physics;
theoretical physics at the Gran Sasso National Lab;
Majorana ideas on neutrinos; GSSI's 10th anniversary

Francesco VISSANI, Laboratori Nazionali del Gran Sasso

Assergi, 02/23/2023

today's birthday

a (neutron) star was born

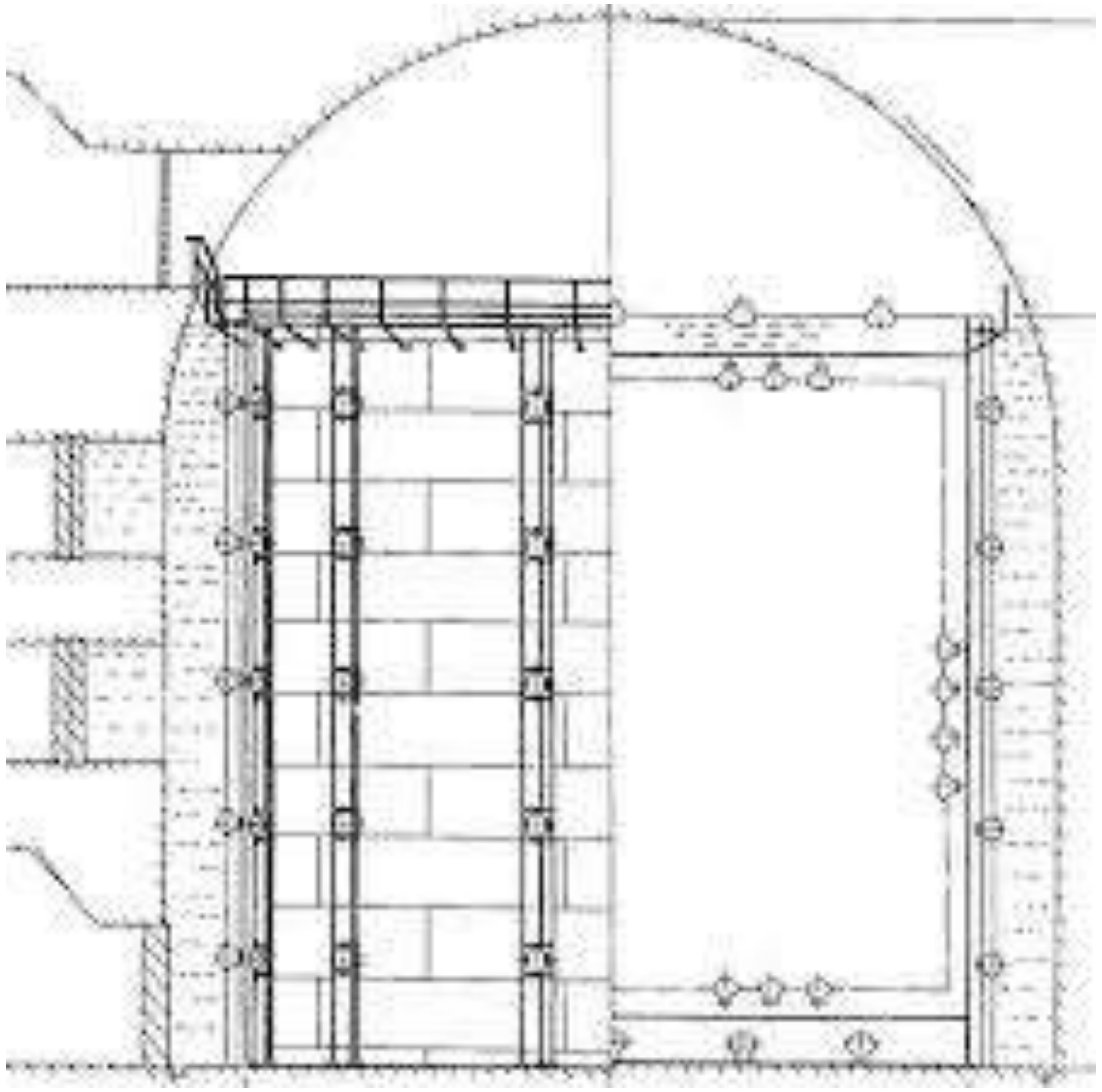
Astronomers Shelton & Duhalde saw SN1987A

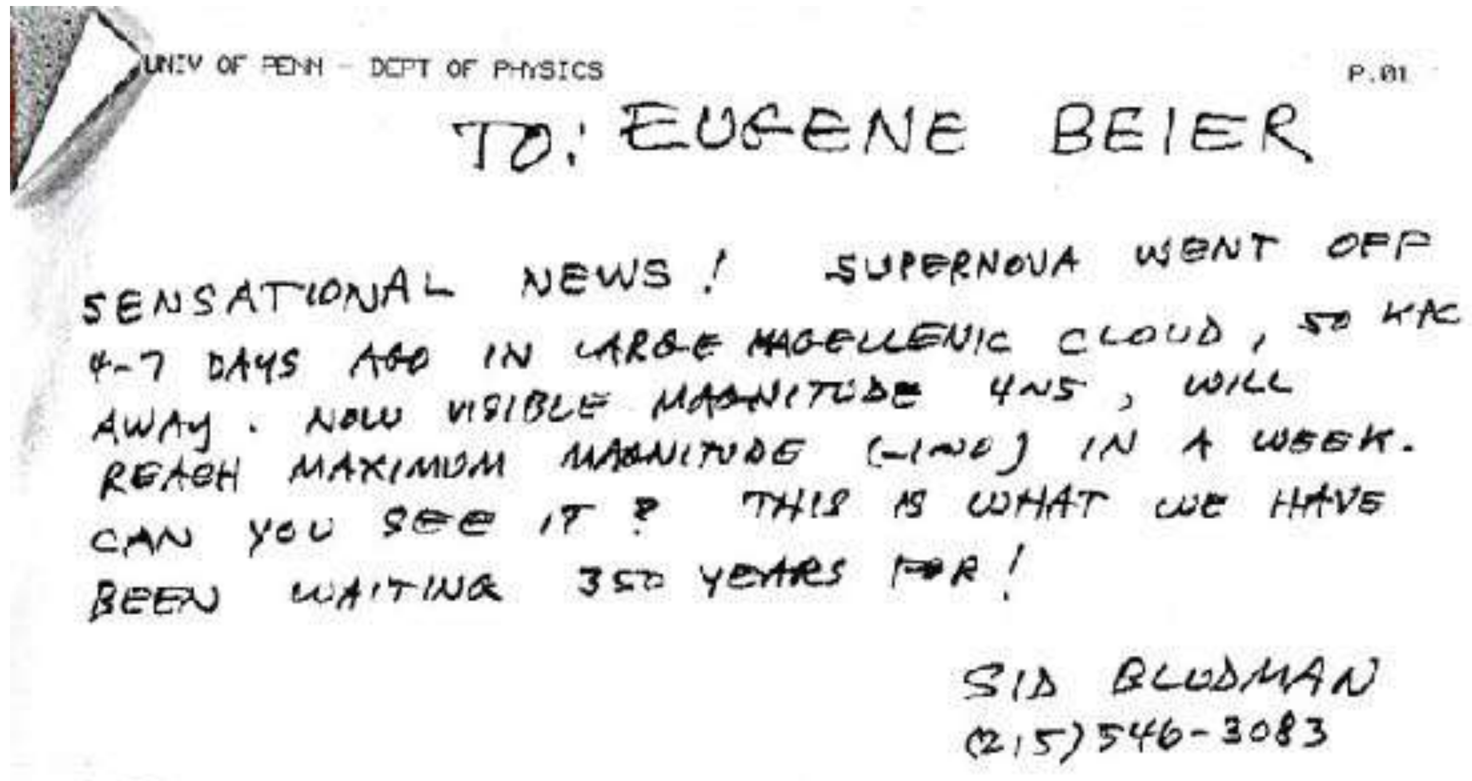
Neutrinos were observed on Feb 23, 1987 at 7 h 35m

God knows the meaning of LSD findings

The expected neutron star was indeed seen

Kamiokande-II and SN1987A



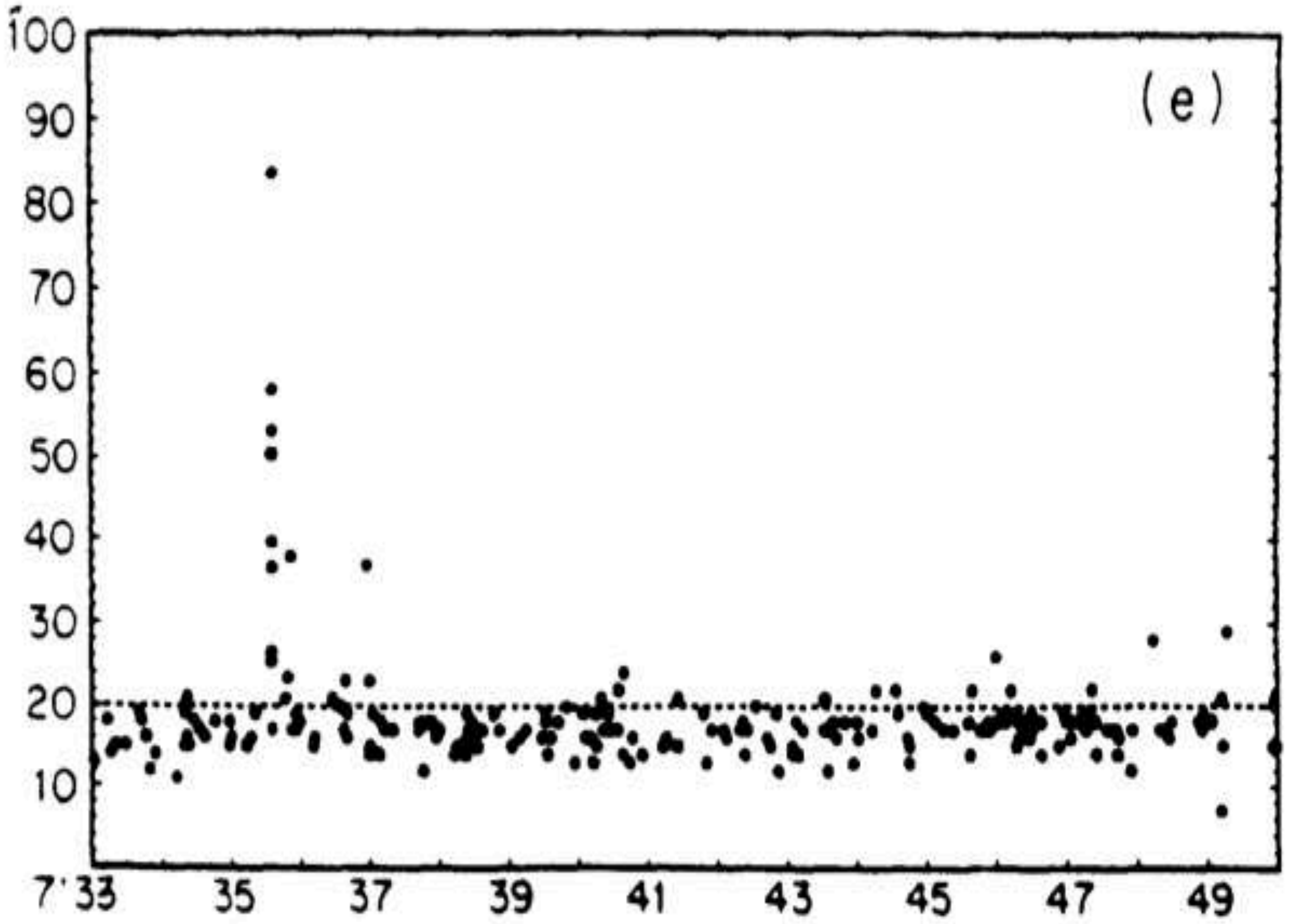


UNIV OF PENN - DEPT OF PHYSICS P.01

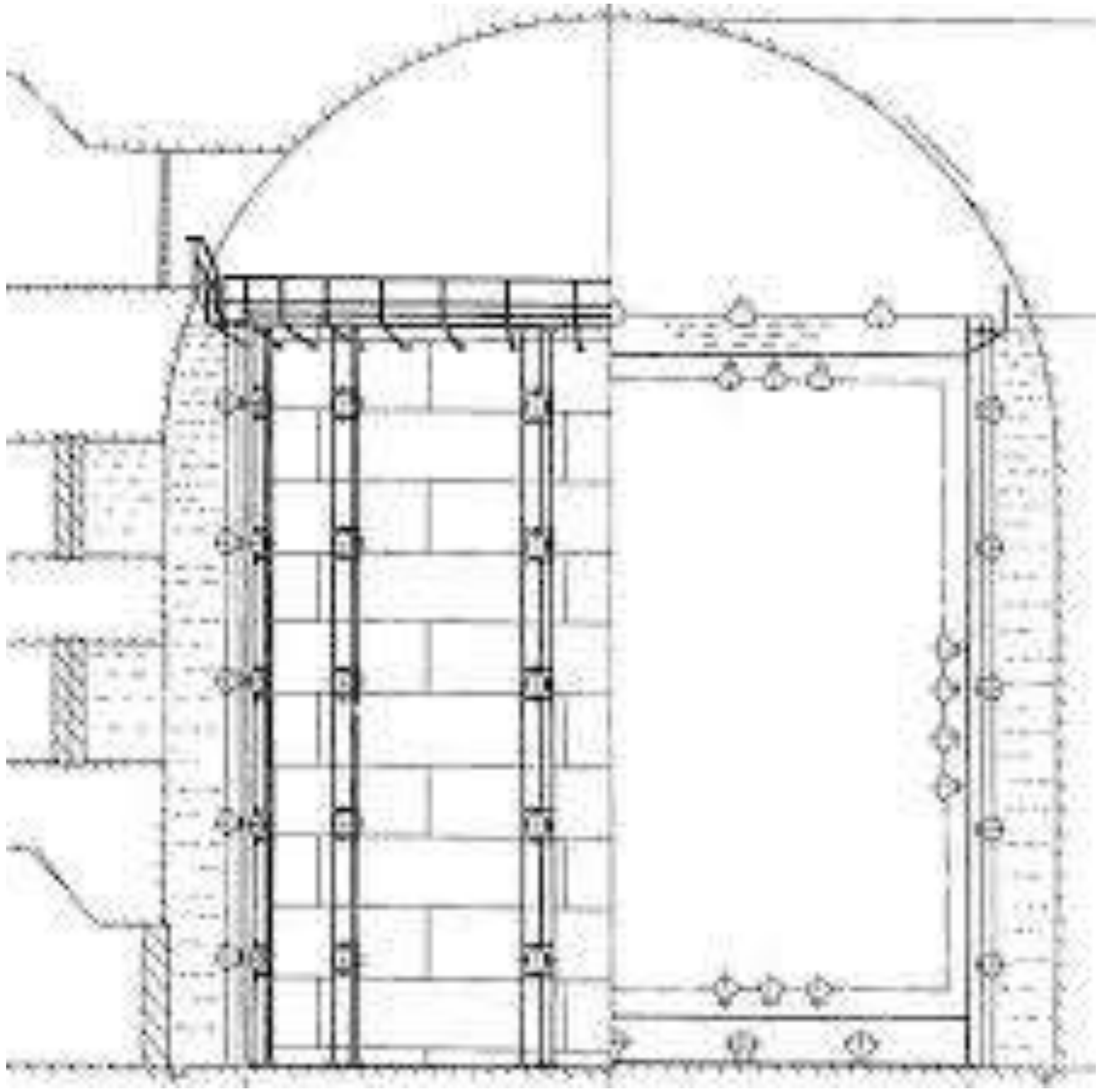
TO: EUGENE BEIER

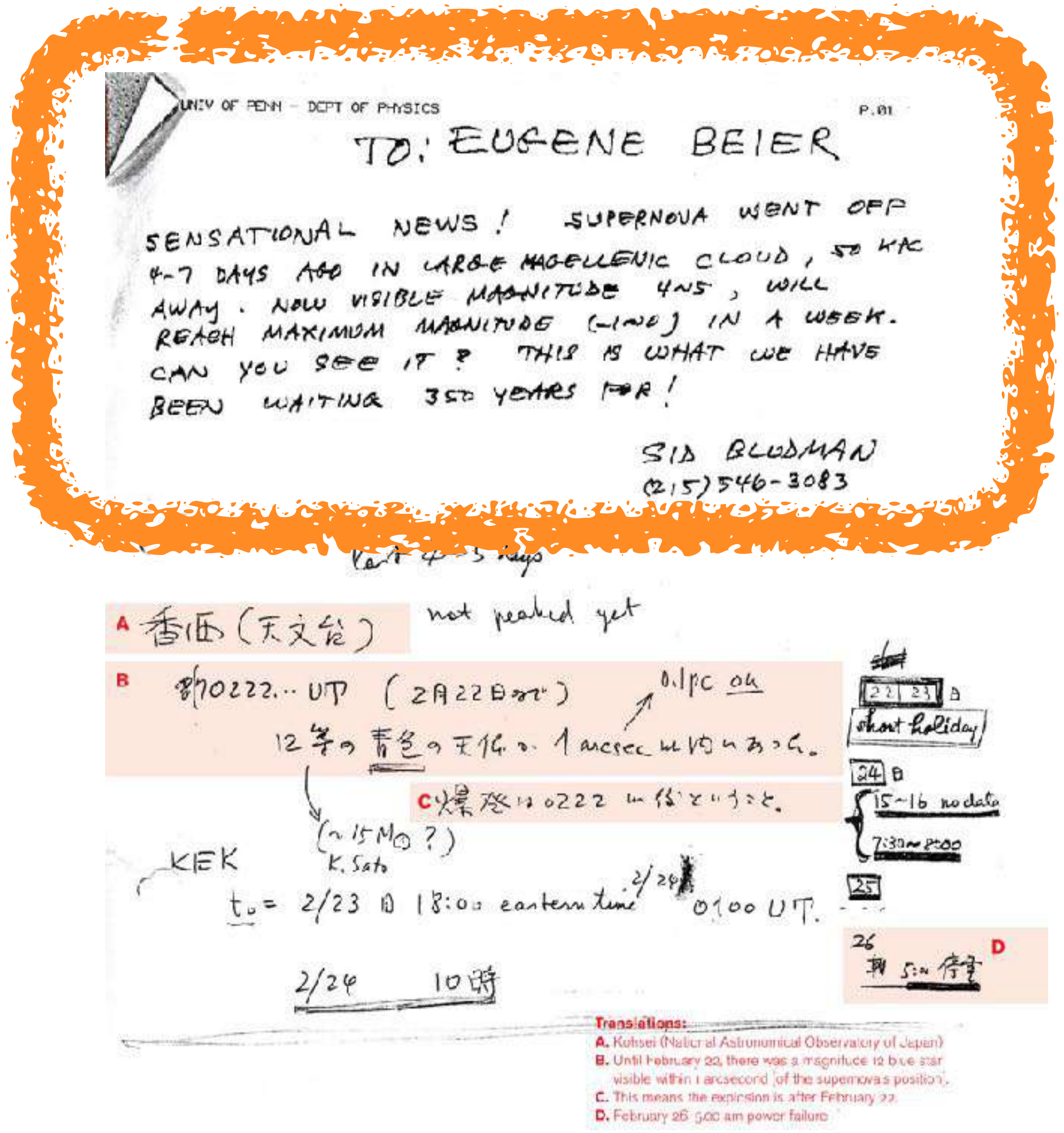
SENSATIONAL NEWS! SUPERNOVA WENT OFF 4-7 DAYS AGO IN LARGE MAGELLENIC CLOUD, 50 KPC AWAY. NOW VISIBLE MAGNITUDE 4~5, WILL REACH MAXIMUM MAGNITUDE (~1 ~0) IN A WEEK. CAN YOU SEE IT? THIS IS WHAT WE HAVE BEEN WAITING 350 YEARS FOR!

SID BLUDMAN
(215) 546-3083



Kamiokande-II and SN1987A





UNIV OF PENN - DEPT OF PHYSICS P.01

TO: EUGENE BEIER

SENSATIONAL NEWS! SUPERNOVA WENT OFF 4-7 DAYS AGO IN LARGE MAGELLENIC CLOUD, 50 KPC AWAY. NOW VISIBLE MAGNITUDE 4½, WILL REACH MAXIMUM MAGNITUDE (~1 or 0) IN A WEEK. CAN YOU SEE IT? THIS IS WHAT WE HAVE BEEN WAITING FOR 350 YEARS FOR!

SID BLUDMAN
(215) 546-3083

A 香西 (天文台) not peaked yet

B

C

short holiday

KEK

t_0 = 2/23 18:00 eastern time 0100 UT.

2/24 10時

D

Translations:

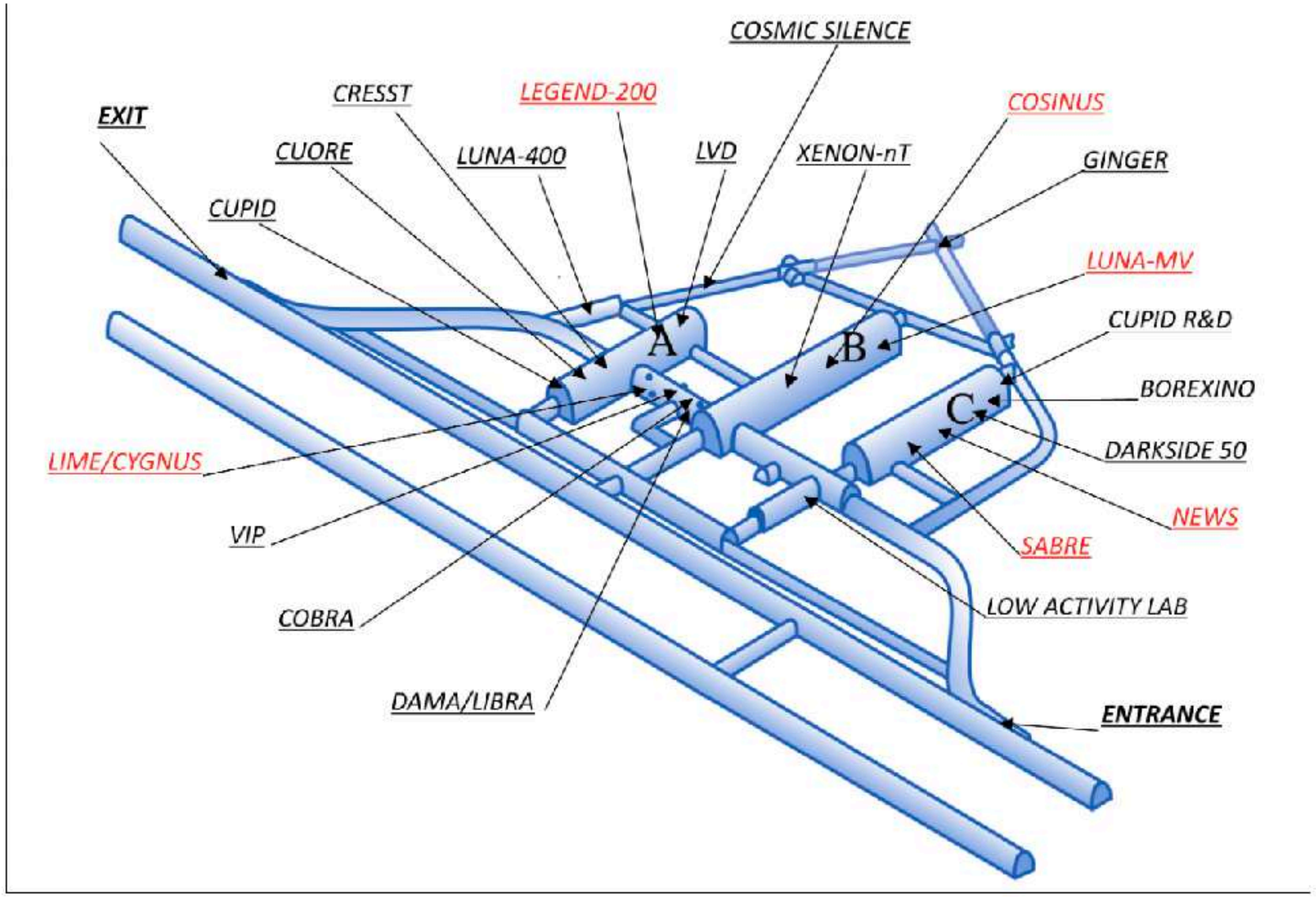
A. Kohsei (National Astronomical Observatory of Japan)
B. Until February 22, there was a magnitude 12 blue star visible within 1 arcsecond of the supernova's position.
C. This means the explosion is after February 22.
D. February 26 5:00 am power failure

theory at LNGS

Research

Experiments in the Gran Sasso National Laboratory have given revolutionary contributions to Neutrino Physics with neutrinos naturally produced in the Sun and in Supernova explosion, search for neutrino mass in neutrinoless double beta decays, to the search for Dark Matter, and to the understanding of the nuclear processes that regulate the evolution of the stars (Nuclear Astrophysics).

Below, the current schematic view of the installation of the experiments in the underground site of Gran Sasso National Laboratory, and the list of running or under construction (in red) ones.



https://www.lngs.infn.it/en/research

Research

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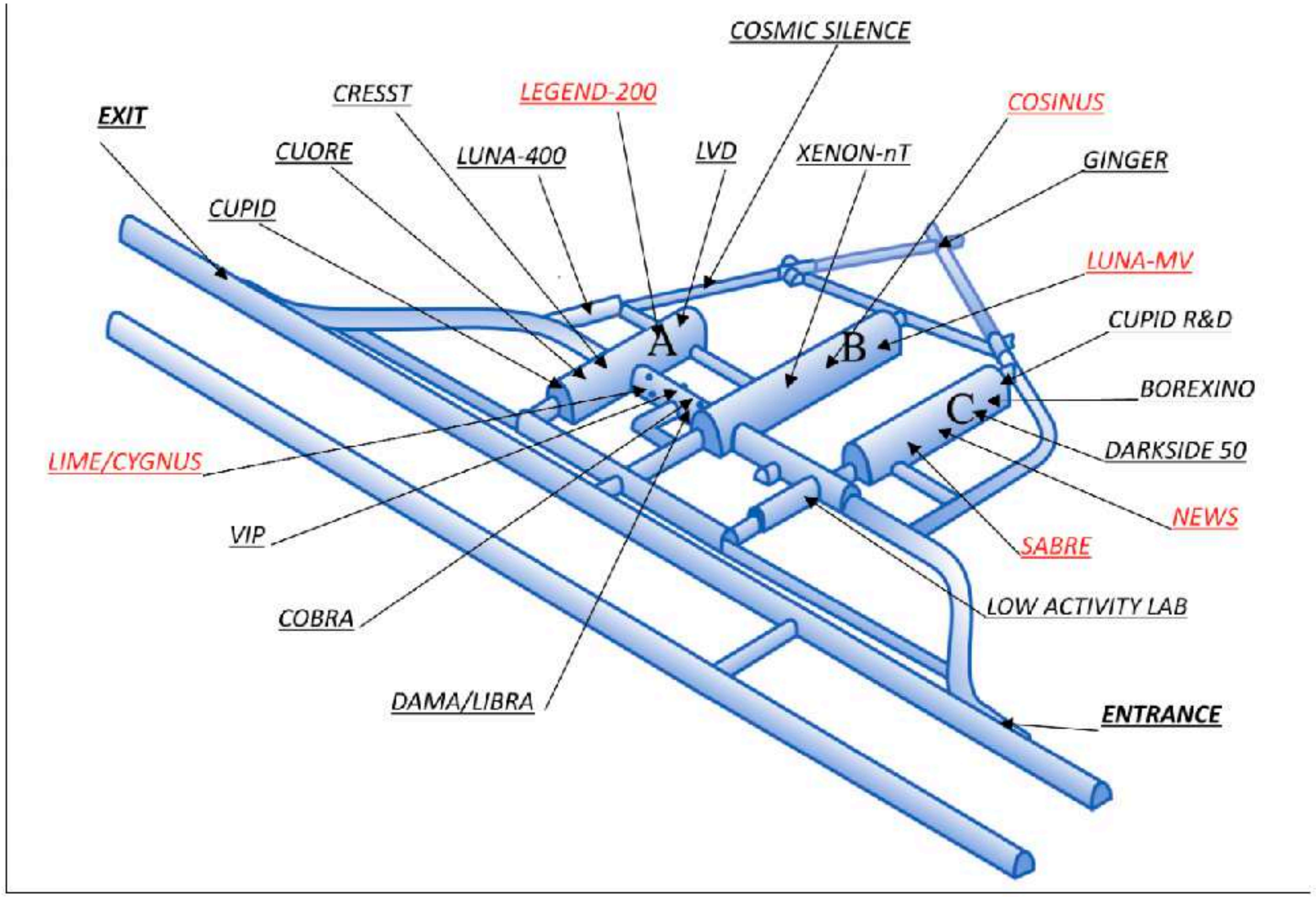

staff theorists at Gran Sasso lab and L'Aquila U

- Massimo Mannarelli
- Giulia Pagliaroli
- Francesco Vissani

- Zurab Berezhiani
- Francesco Capozzi
- Fabrizio Nesti
- Luigi Pilo
- Francesco Villante

astrophysics, astroparticle physics, neutrino physics, gamma rays, standard and modified gravity, cosmology, dark matter, particle physics, gauge groups, quantum field theory, beyond standard model phenomenology, accelerator and flavor physics, participation in experimental activities, etc.

my favourite research topic is

neutrinos

ELSEVIER

New Astronomy
Volume 83, February 2021, 101498

On the rate of core collapse supernovae in the milky way

Karolina Rozwadowska [a, b], Francesco Vissani [a, b], Enrico Cappellaro [c]

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https://doi.org/10.1016/j.newast.2020.101498   Get rights and content

Highlights

- For neutrino astronomy, the knowledge of the rate of core collapse supernovae is of essential importance.
- We use the best available information to update its study and to obtain the state-of-the-art value: R = 1.63 ± 0.46/century.
- We discuss the consistency of the results and point out the critical aspects in this inference.

NEUTRINOS IN PHYSICS AND ASTROPHYSICS

This book covers the field of neutrino physics and astrophysics, providing an up-to-date presentation of the different research topics on the frontier of the field. It starts with a historical description to understand how the different aspects of our knowledge about the neutrinos evolved up to the present state. The main required elements of the Standard Model of electroweak interactions are introduced, and the different neutrino interactions and detection techniques are presented. We introduce the various ways to give neutrinos a mass and the phenomenon of neutrino oscillations which provides the main evidence for non-vanishing neutrino masses. We then consider the neutrinos produced in the Sun, what we have learned from them, and how they can also be useful to study our star. The geoneutrinos produced by the radioactivity in the Earth are discussed and the status of their detection is presented. We survey the neutrino production in the supernova explosions at the end of the life of very massive stars, what has been observed in SN1987A, and what could be learned from a future supernova or from the observation of the diffuse supernova neutrino background. We describe in detail the neutrino production by cosmic rays interacting in the atmosphere, the evidence for their flavor oscillations, and the oscillograms to describe their flavor change in terrestrial matter. The different mechanisms of production of high-energy astrophysical neutrinos and the observations achieved with the IceCube detector are presented, also discussing their flavor content by means of the flavor triangle. We then examine the cosmological neutrino background, its impact on Big Bang nucleosynthesis and on the CMB observations, with the associated bound on their masses and effective number. Finally, we review the basics of the leptogenesis scenarios, which provide an attractive explanation for the observed baryon asymmetry of the Universe.

World Scientific
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12982 hc

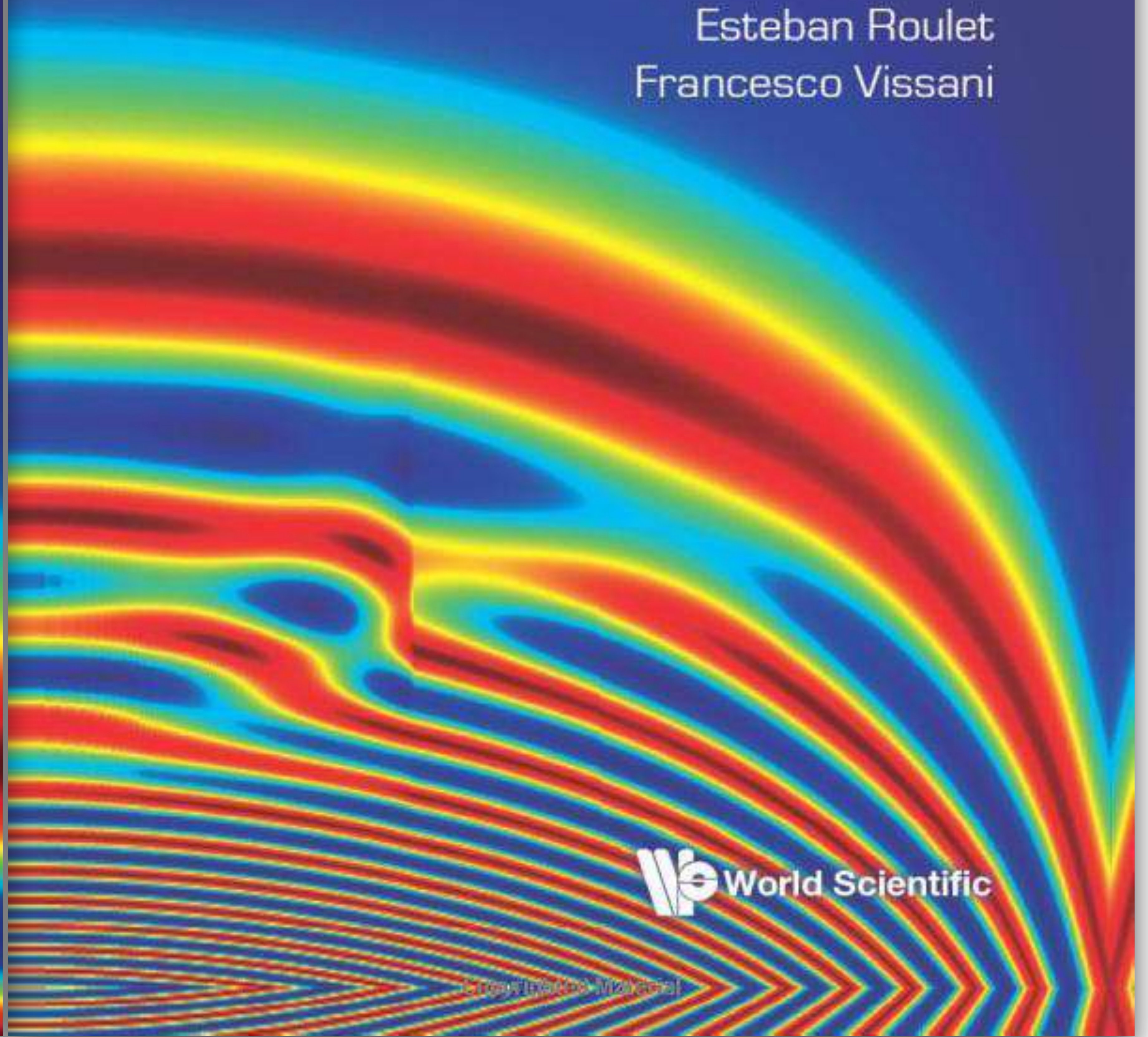
ISBN 978-981-126-093-3
9 789811 260933

NEUTRINOS IN PHYSICS AND ASTROPHYSICS

Roulet
Vissani

NEUTRINOS IN PHYSICS AND ASTROPHYSICS

Esteban Roulet
Francesco Vissani



World Scientific

Neutrinos in Physics and Astrophysics

https://doi.org/10.1142/12982 | October 2022

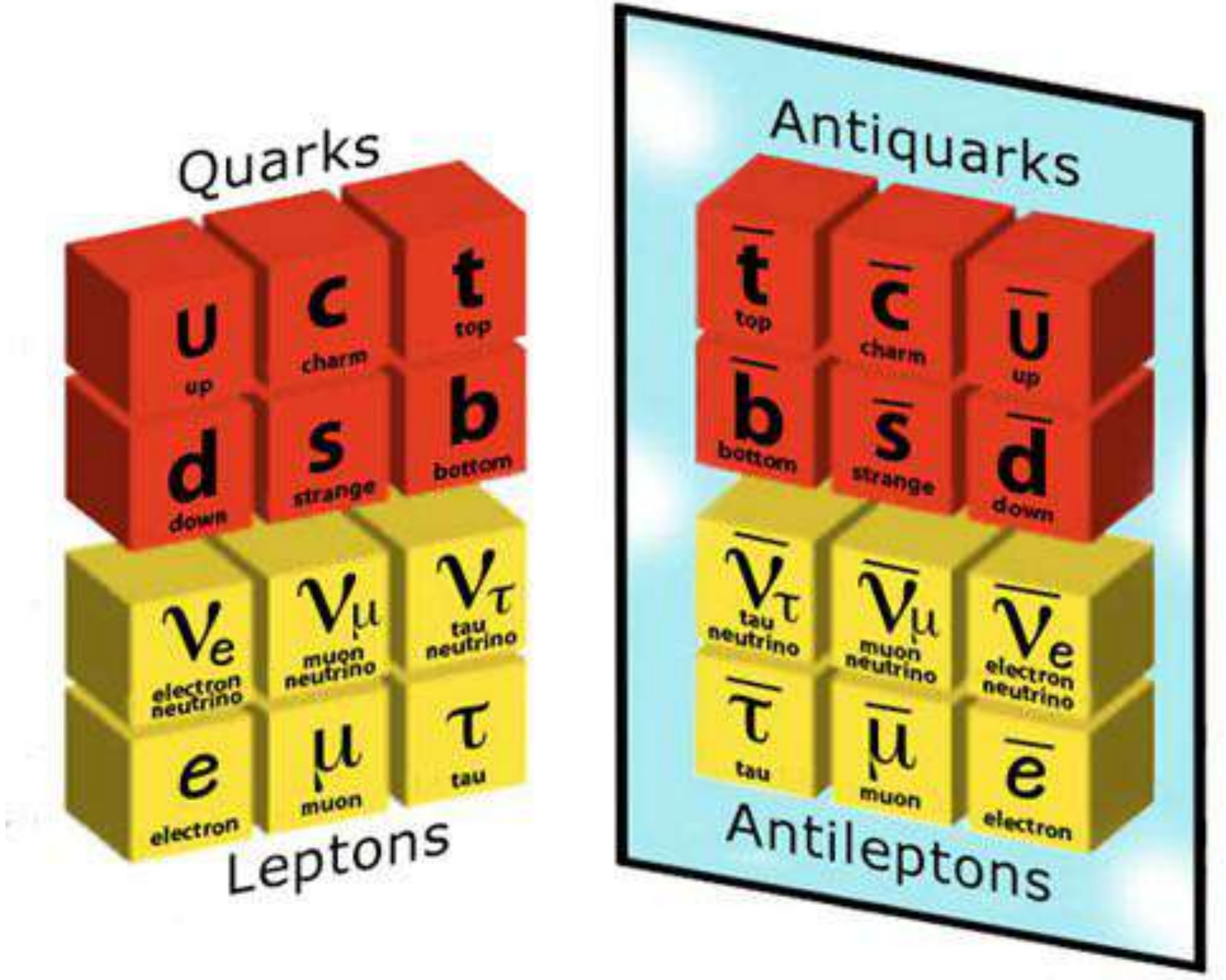
Pages: 250

By (author): Esteban Roulet (*CONICET, Argentina*) and Francesco Vissani (*INFN, Italy*)

ISBN: 978-981-126-093-3 (hardcover)

but today I'd like to focus on
neutrinos in particle physics, and more specifically of:

Majorana ideas on neutrinos

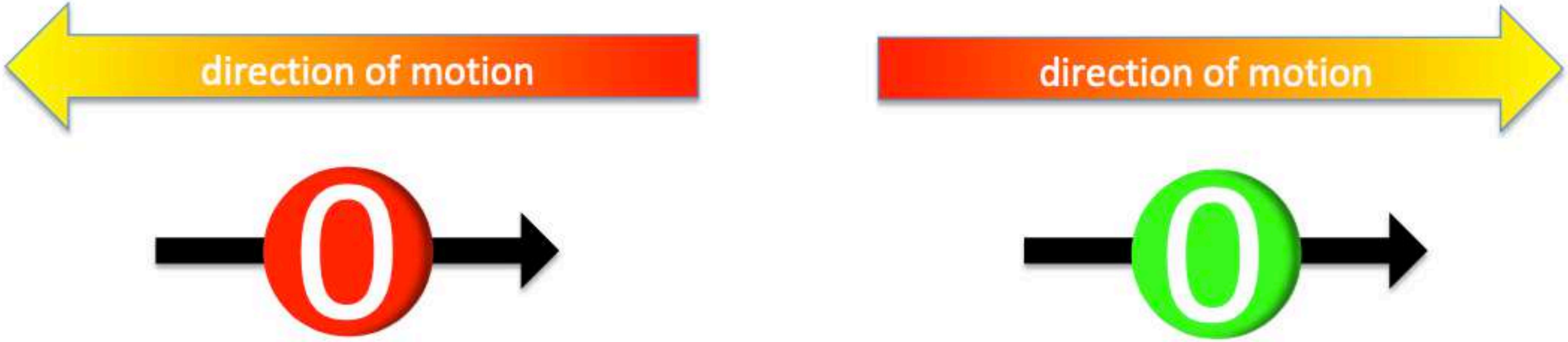


Matter and antimatter particles
Credit: Fermilab

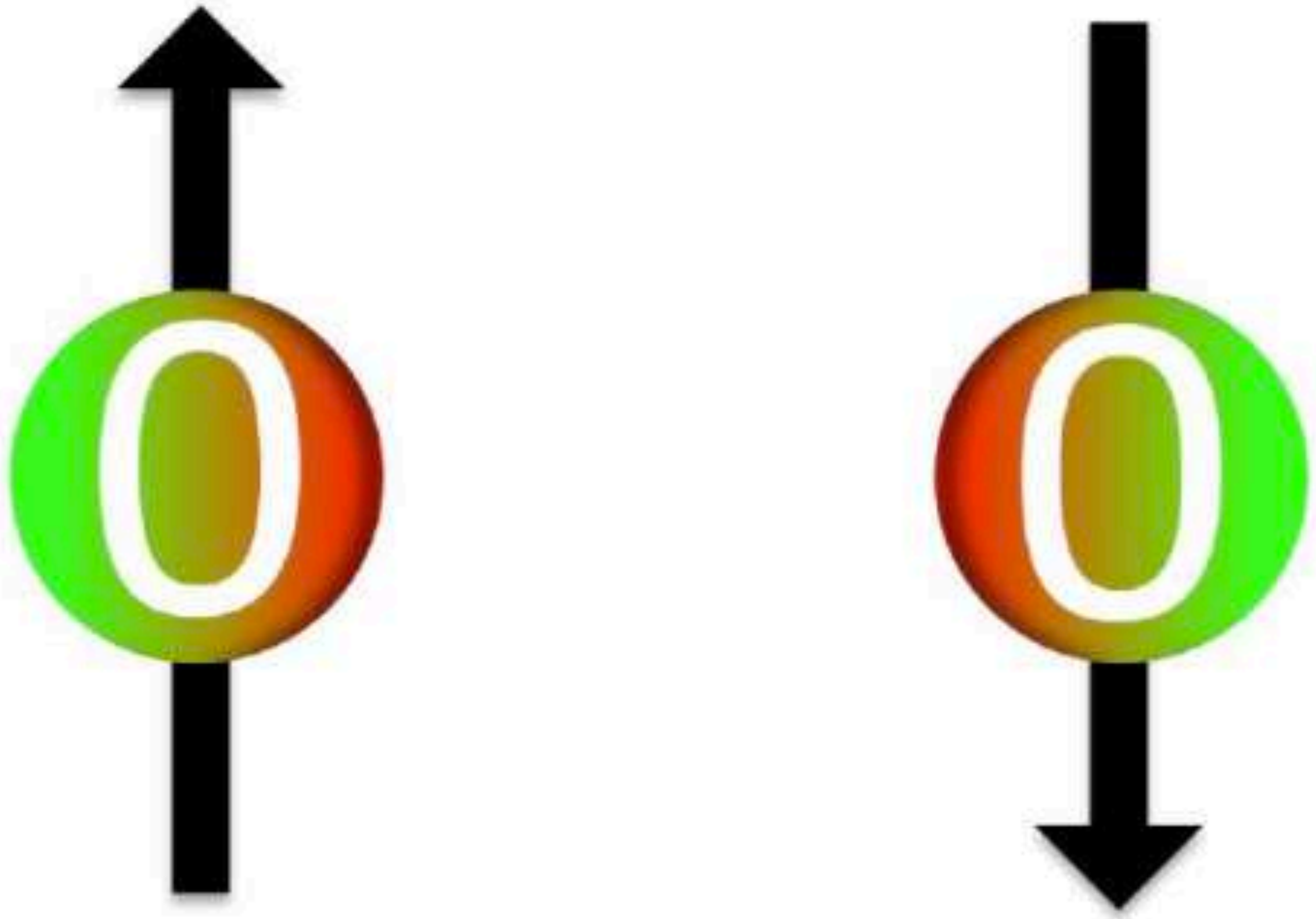
This picture conveys a huge amount of info, evoking the concepts of:

- *particles/antiparticles*
- *quarks/leptons*
- *family replication*

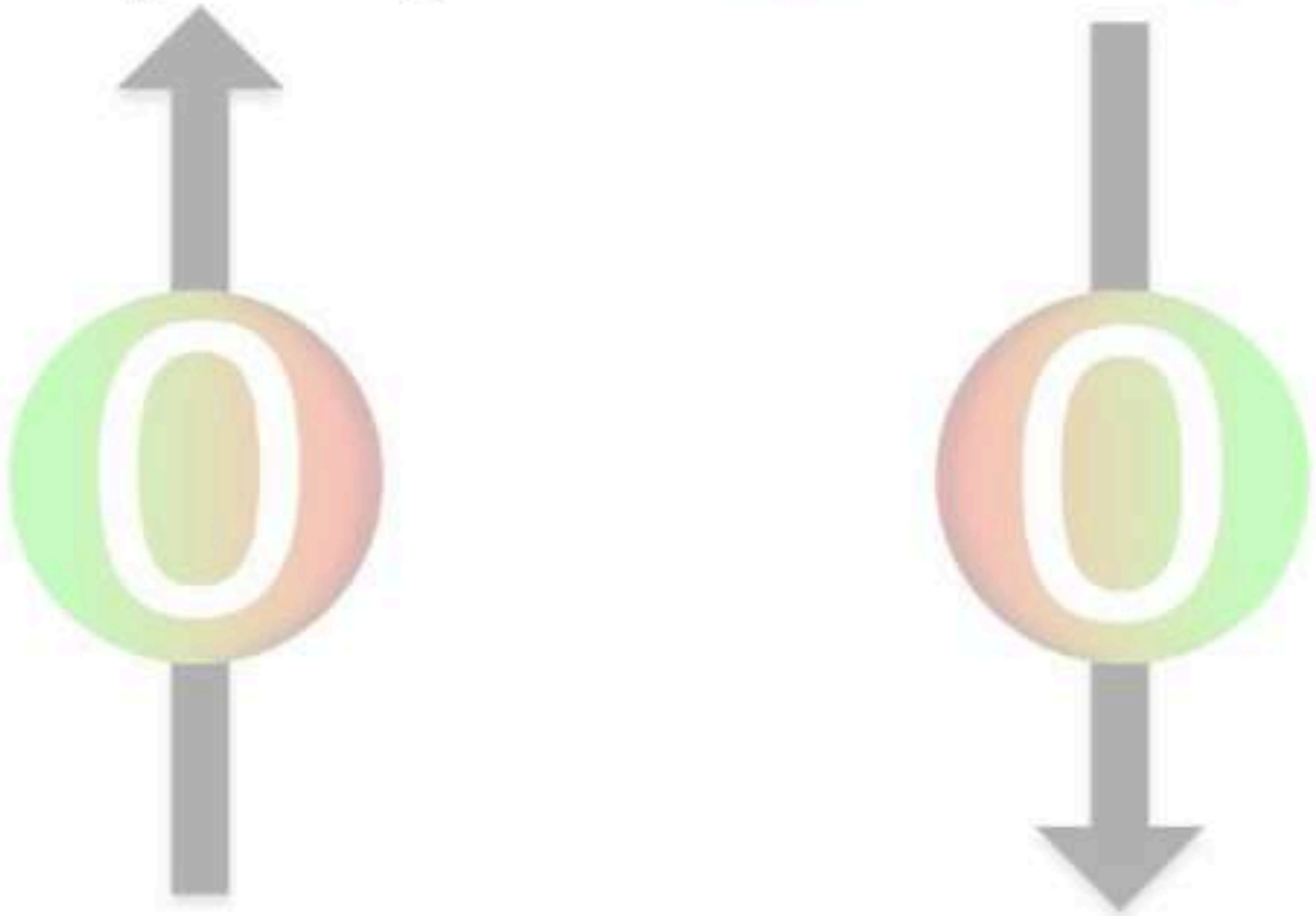
But it raises a question:
what tells neutrinos from antineutrinos as they are both chargeless?



neutrinos and antineutrinos distinguished by their helicities and in their rest frame? they could be indistinguishable...



Majorana theory: they're matter & antimatter at once



Open Access Review

What Is Matter According to Particle Physics, and Why Try to Observe Its Creation in a Lab?

by Francesco Vissani

INFN, Laboratori Nazionali del Gran Sasso, 67100 L'Aquila, Italy

Academic Editor: Marek Gazdzicki

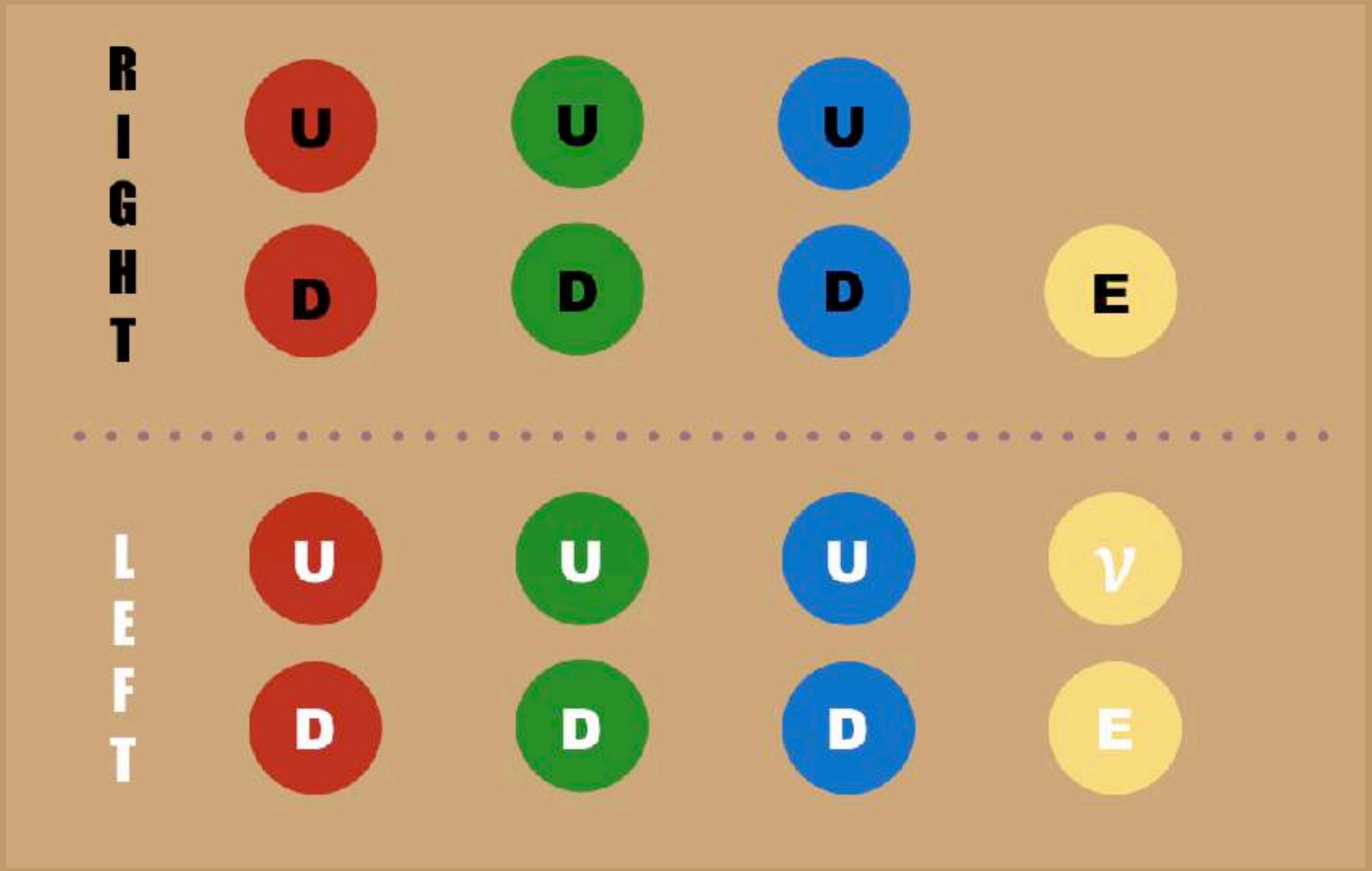
Universe **2021**, 7(3), 61; https://doi.org/10.3390/universe7030061

https://www.mdpi.com/2218-1997/7/3/61

WHAT IS "MATTER" MADE OF?

Elementary Components Of Matter	Identifying Feature	End Vigence Of Model [Theory] Experiment	Reason For Inadequacy
Atoms	Type, Mass	[1838] 1909	**[Atoms Of Electricity] Electrons**
Electrons & Nuclei	Charge, Mass, Spin1/2	[1930] 1956	**[Fermi' Theory] Neutrons & Neutrinos**
$p, n, e, \nu_e, \mu \ldots$	$B, L_e, L_\mu \ldots$, ""	[1961] 1968	**[Standard Model] Quarks**
Quarks & Leptons	$B-L, L_e-L_\mu, \ldots$, ""	[1962] 2010	**[Leptonic Mixing] Appearance Experiments**
Quark-Leptons	$B-L$, ""	[1937] ?	**[Majorana' Mass]** $2n \rightarrow 2p + 2e$
Fermions	Mass, Spin1/2	[1977] ???	**[Supersymmetry?] ???**

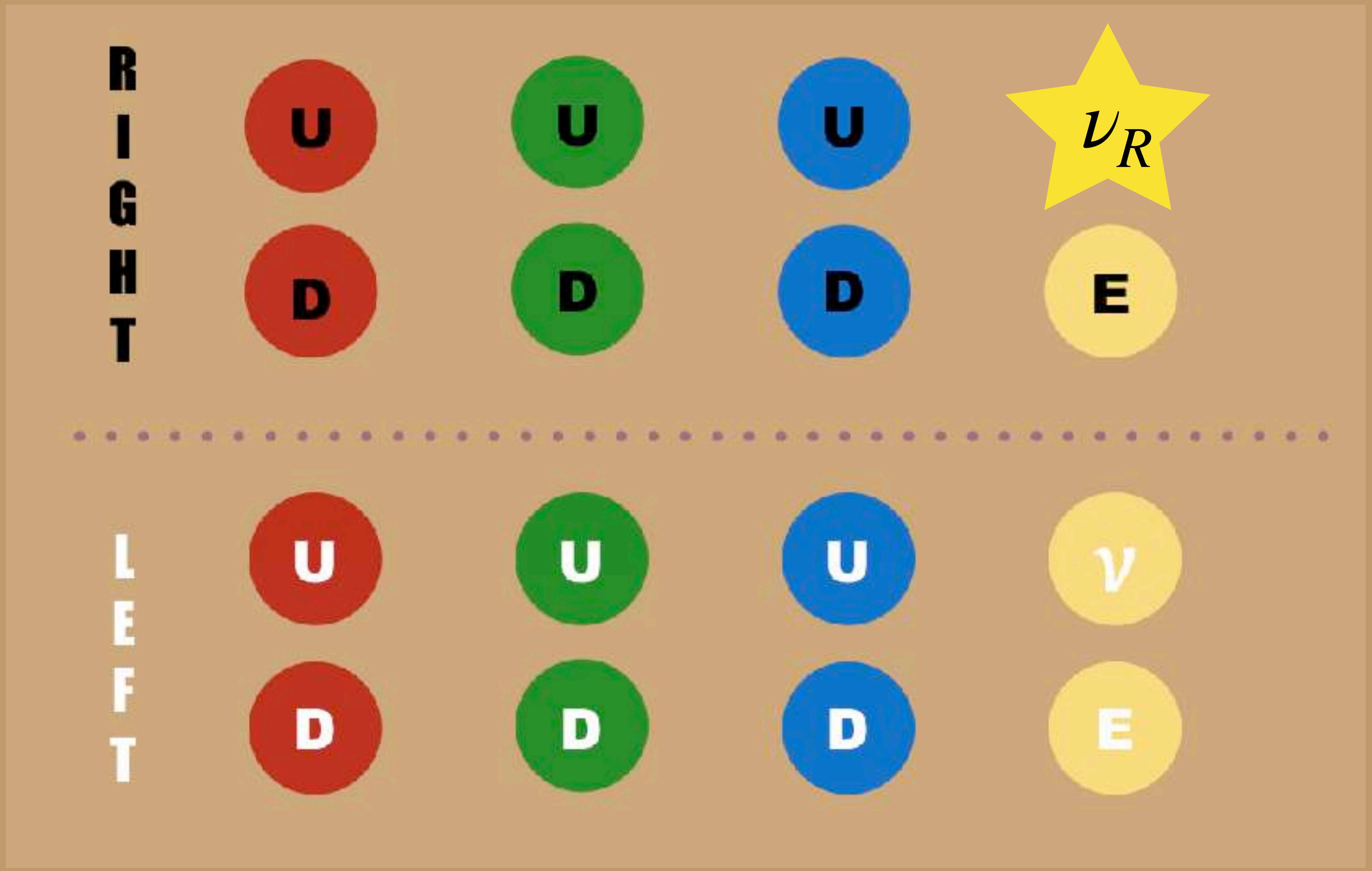
heavy neutrinos



this diagram depicts more accurately which are
the particles of the standard model in each family

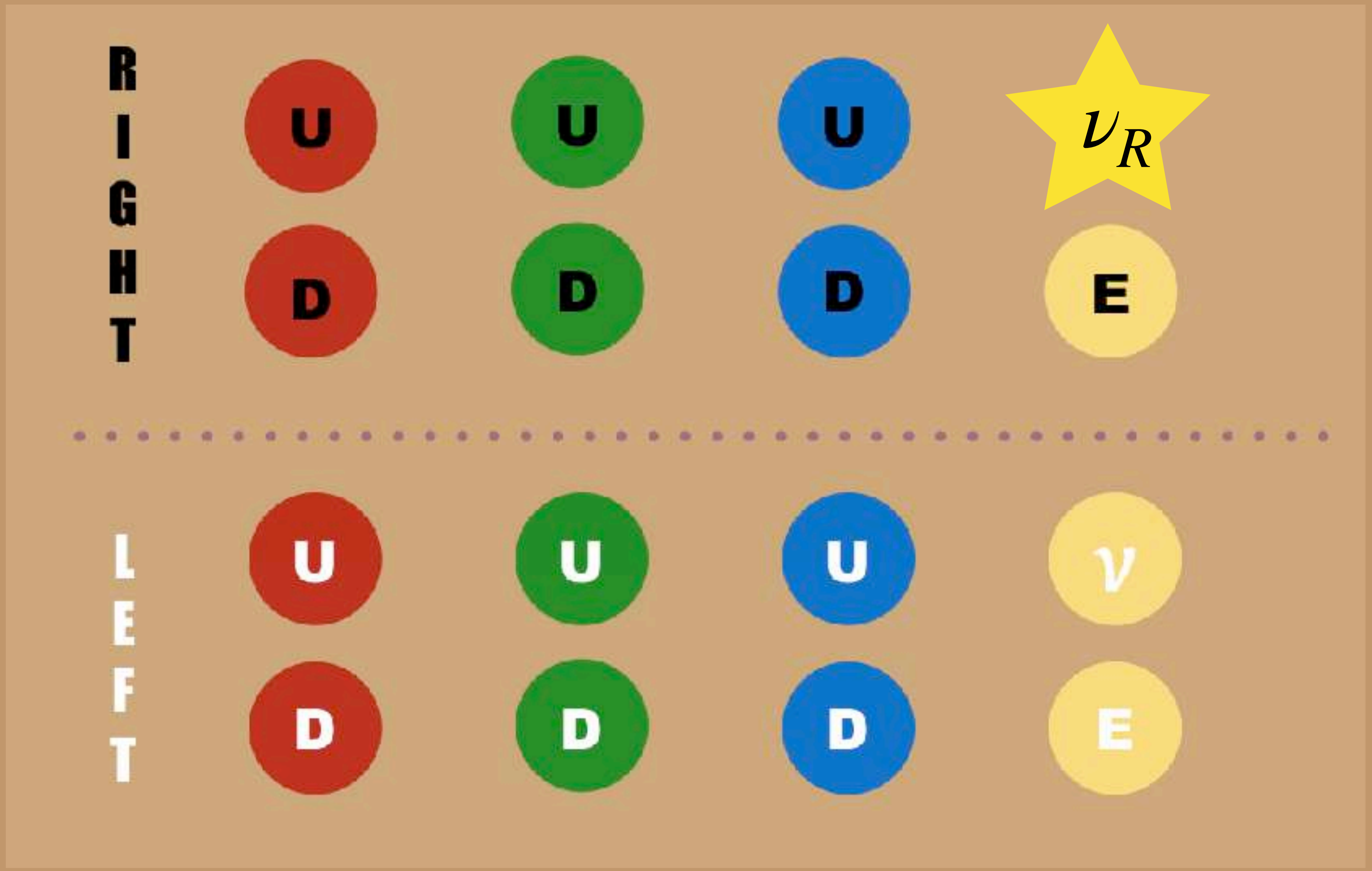
this new representation highlights
a significant asymmetry concerning neutrinos

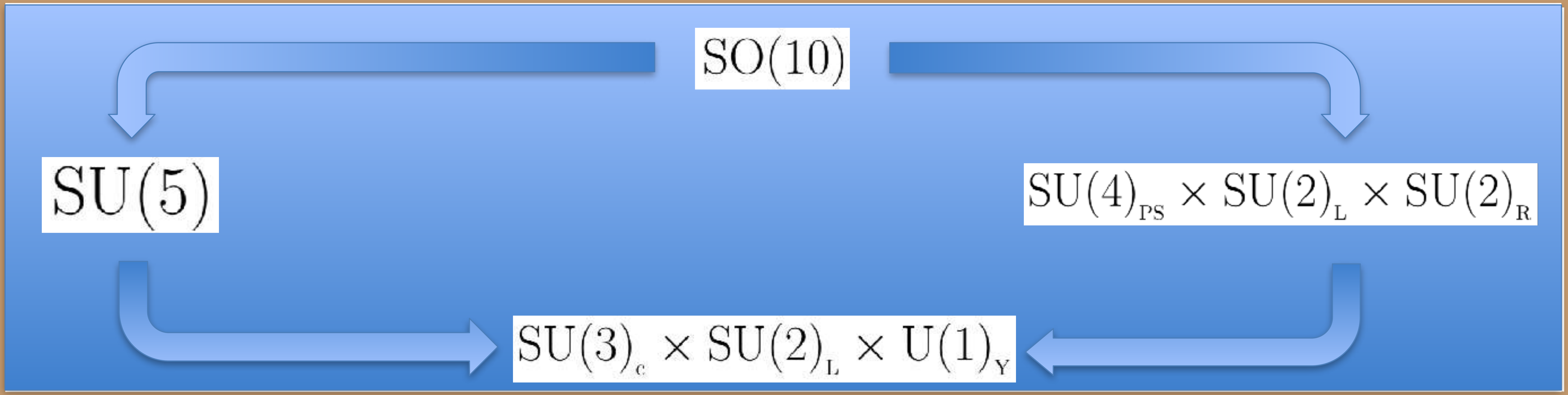
Glashow 1961; Weinberg 1967; Salam 1967; Gross & Wilczek 1973; Politzer 1973



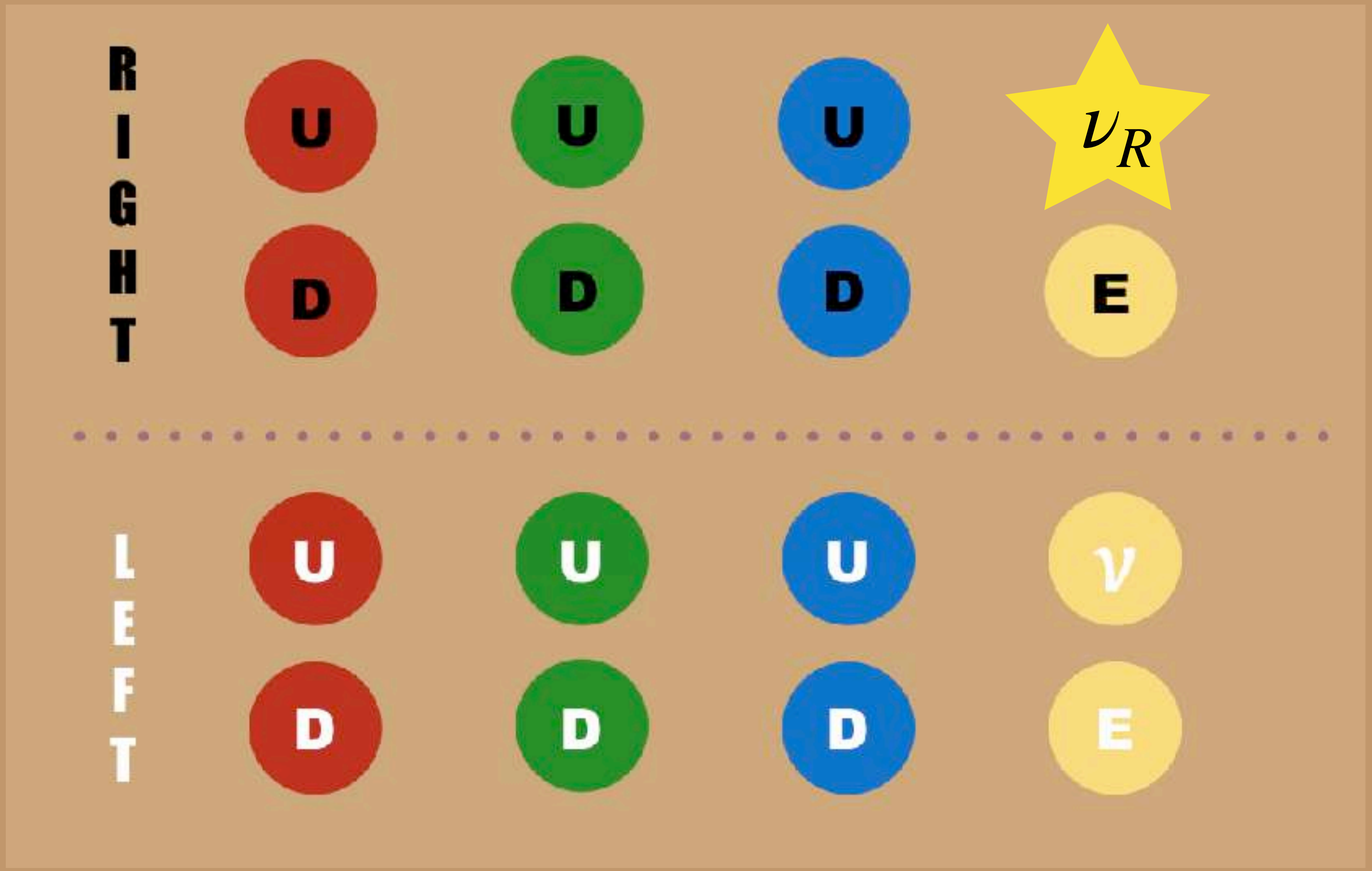
$$\mathrm{SU(2)_L} \text{ acts on } \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} \quad \text{while} \quad \mathrm{SU(2)_R} \text{ acts on } \begin{pmatrix} \nu_R \\ e_R \end{pmatrix}$$

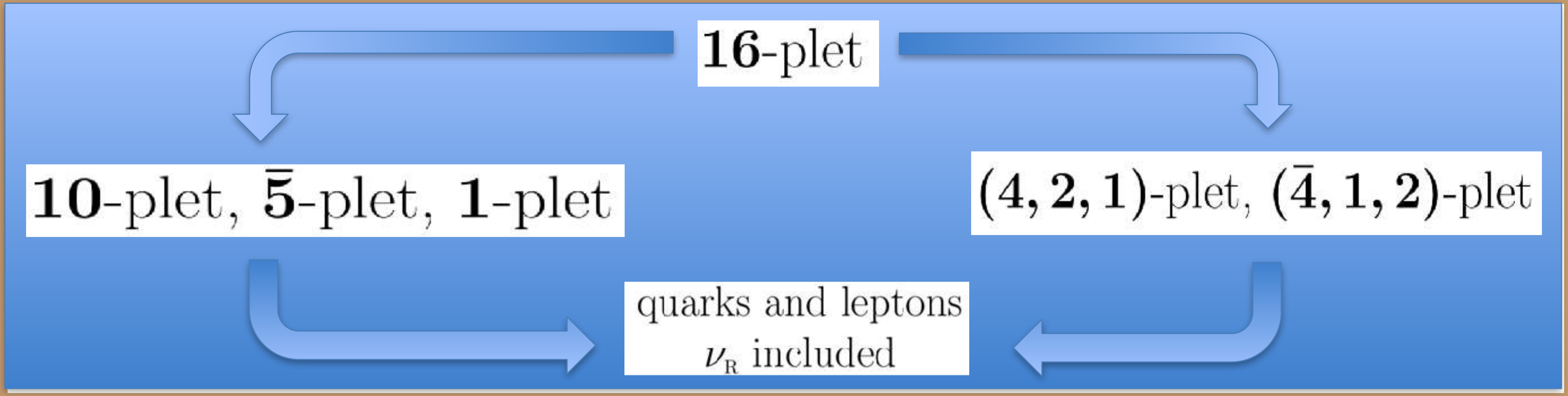
Mohapatra & Pati 1975; Senjanovic & Mohapatra 1975





Glashow 1961; Weinberg 1967; Salam 1967; Gross & Wilczek 1973; Politzer 1973





Glashow 1961; Weinberg 1967; Salam 1967; Gross & Wilczek 1973; Politzer 1973

on the mass scale of heavy neutrinos

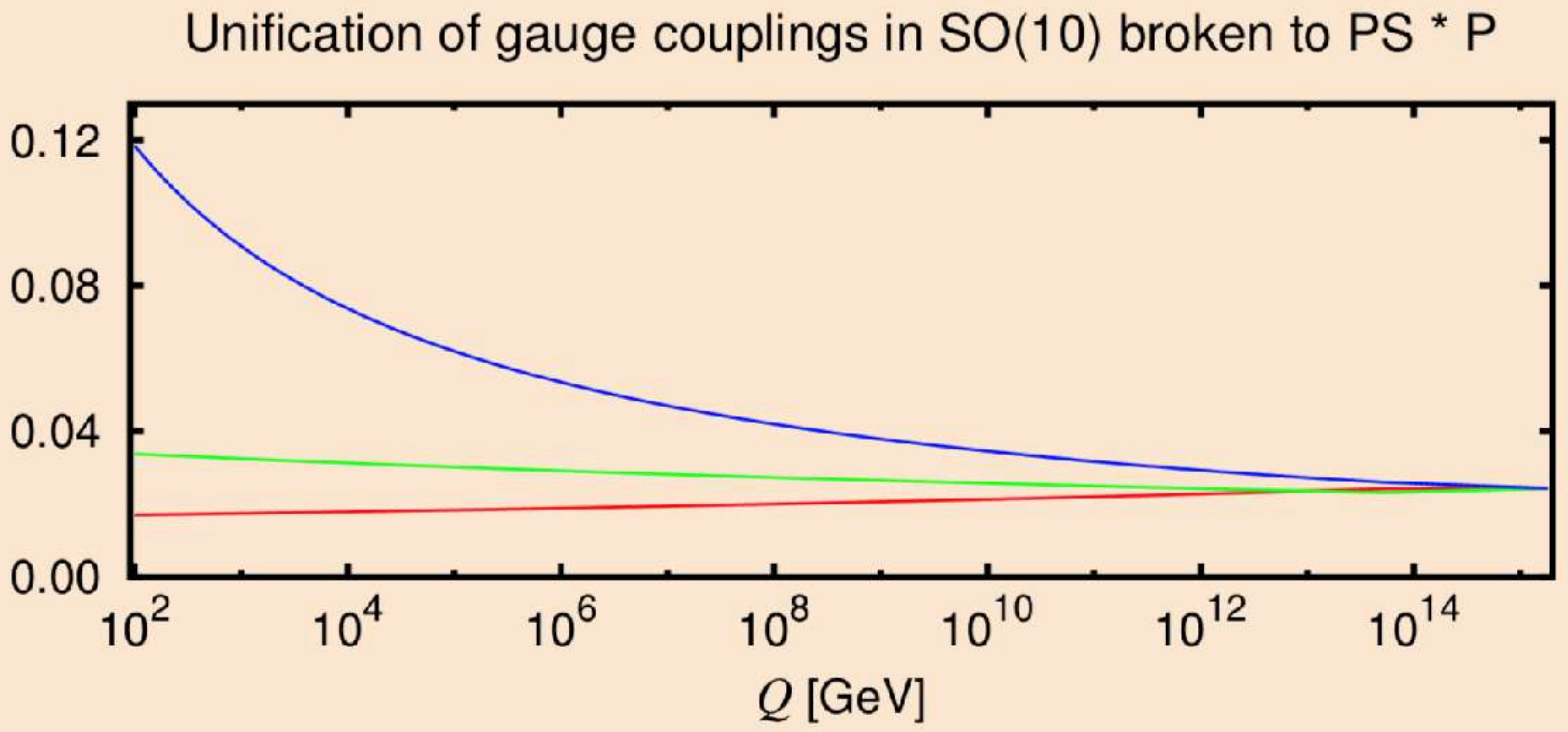


Figure 2: Evolution of the gauge coupling constants in a GUT model with intermediate scale. Here, $M_{\text{interm.}} \approx 5 \times 10^{13}$ GeV.

a plausible scenario for baryogenesis

(Fukugita-Yanagida's implementation of Sakharov's program)

(1) During big-bang, the decay of heavy (right-handed) neutrinos create ΔL

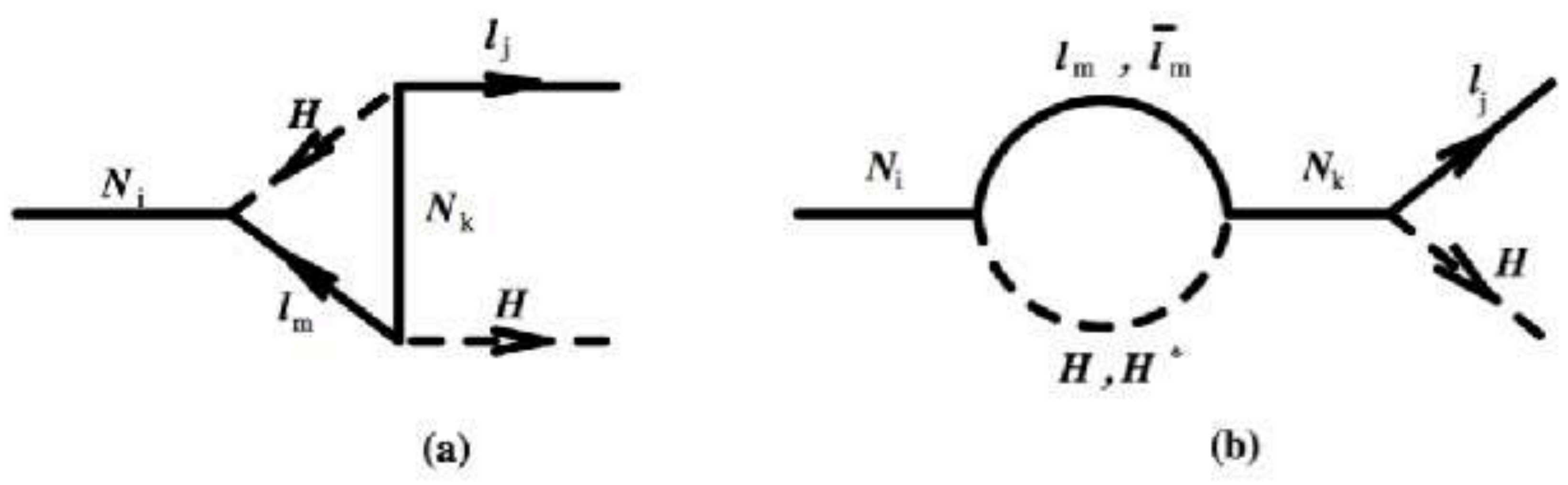


Figure 1: Diagrams contributing to the vertex (Fig. 1a) and wave function (Fig. 1b) CP violation in the heavy singlet neutrino decay.

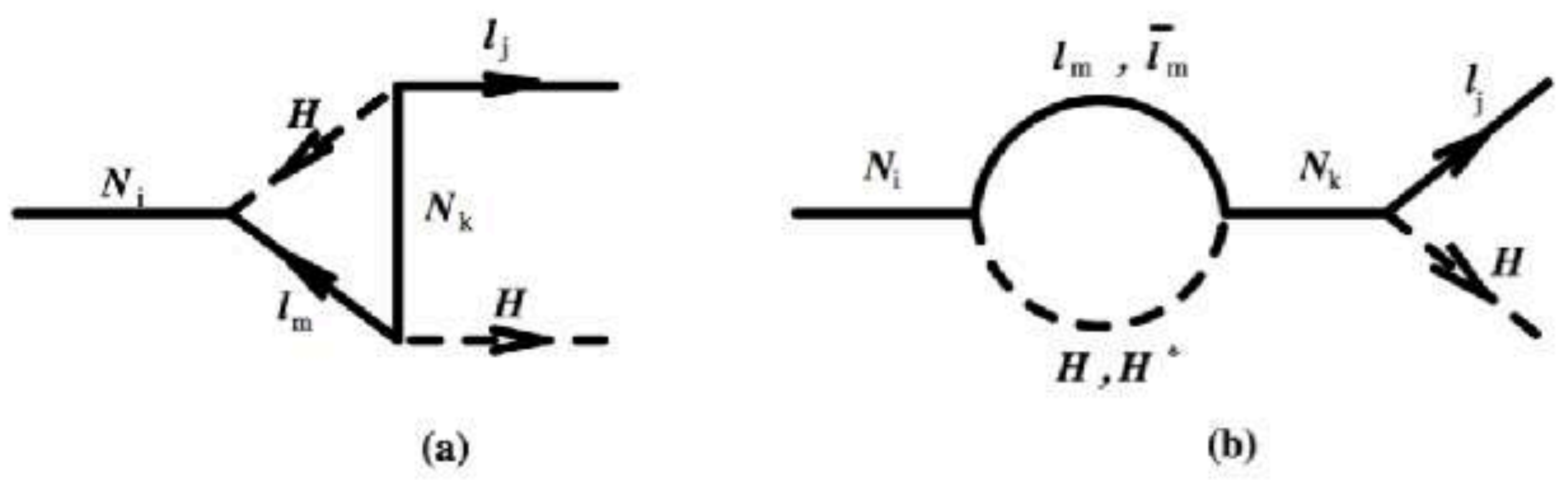
Covi et al. '96

a plausible scenario for baryogenesis

(Fukugita-Yanagida's implementation of Sakharov's program)

(1) During big-bang, the decay of heavy (right-handed) neutrinos create $\Delta\mathbf{L}$

(2) Subsequently, $\mathbf{B}+\mathbf{L}$ violating effects convert it into $\Delta\mathbf{B}$



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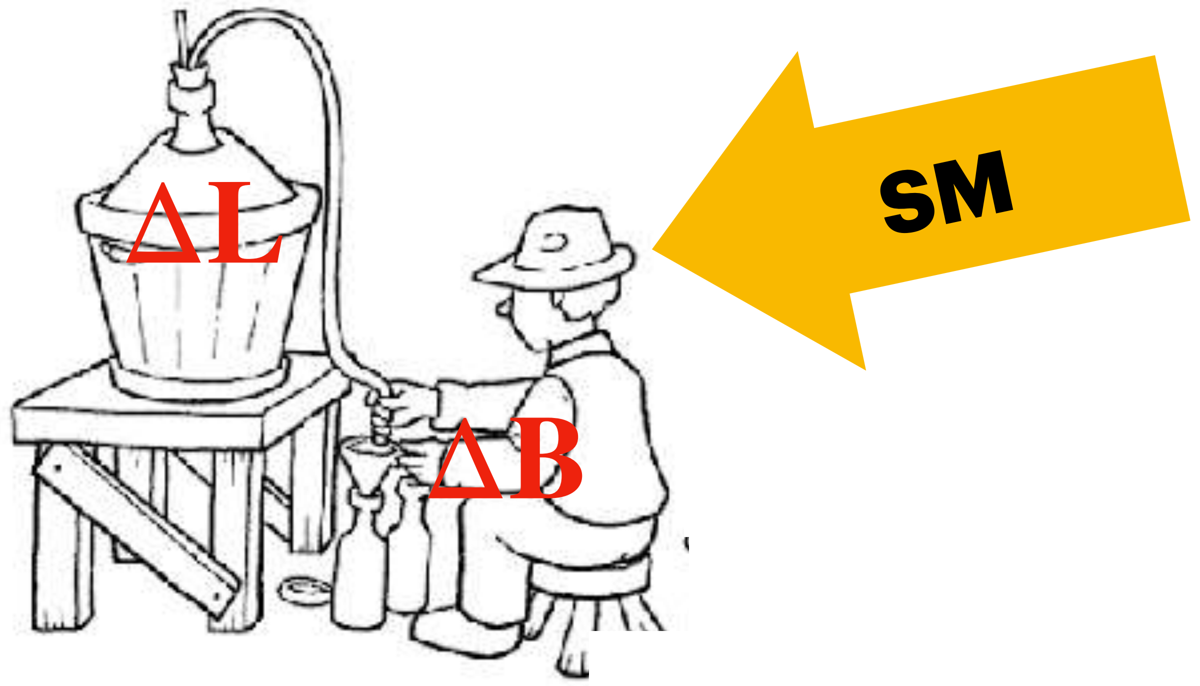
Covi et al. '96



Do experiments suggest a hierarchy problem?

Francesco Vissani
International Centre for Theoretical Physics, Strada Costiera 11, I-34013 Trieste, Italy

(Received 18 September 1997; published 14 April 1998)

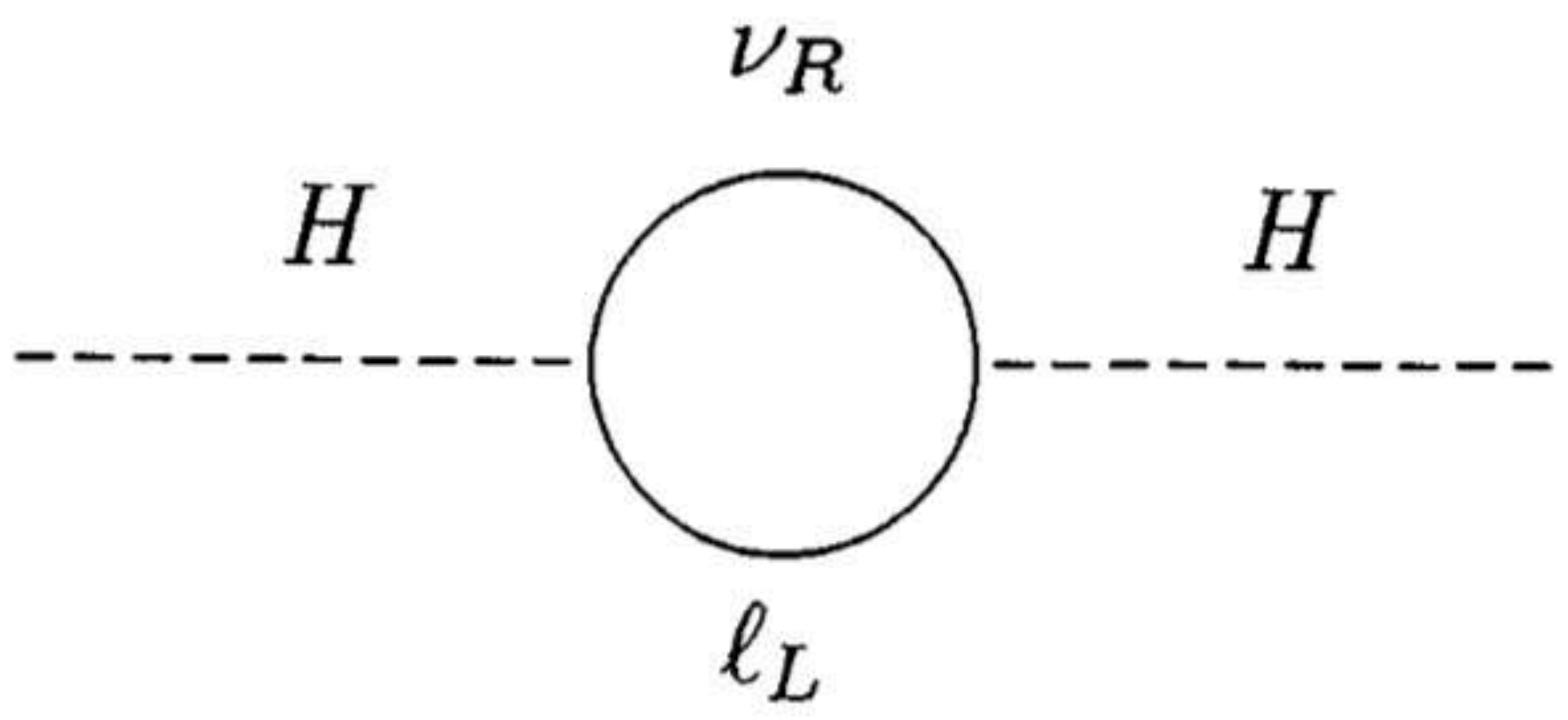


FIG. 1. The Feynman diagram originating the corrections in Eq. (1); ν_R denotes the right-handed neutrino of mass M_R, $\ell_L = (\nu_L, e_L)$ the leptonic and H the Higgs doublets.

PHYSICAL REVIEW D VOLUME 57, NUMBER 11 1 JUNE 1998

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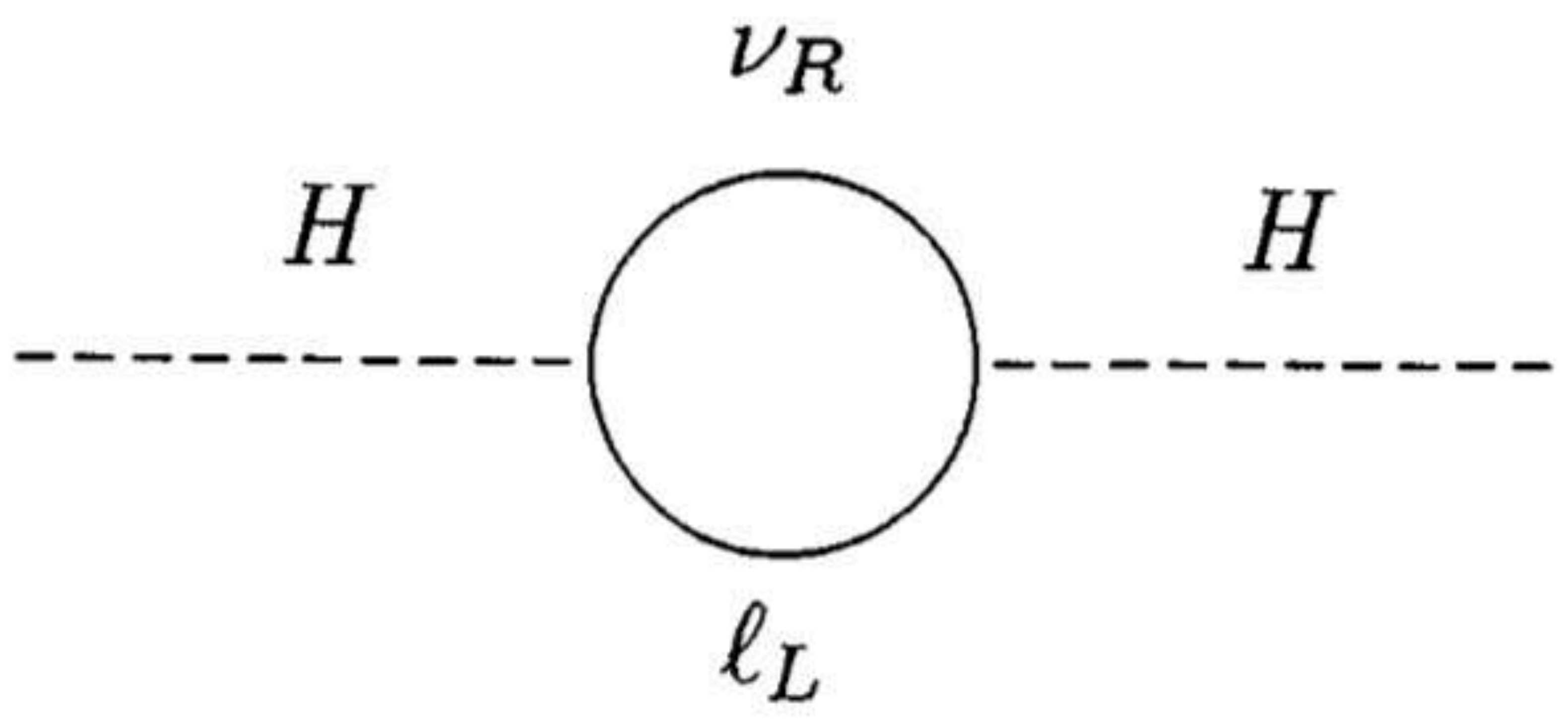

FIG. 1. The Feynman diagram originating the corrections in Eq. (1); ν_R denotes the right-handed neutrino of mass M_R, $\ell_L = (\nu_L, e_L)$ the leptonic and H the Higgs doublets.

what about the cosmological constant?

observavable manifestations

the SM as an effective theory

$$\delta\mathscr{L} \ni \frac{(\ell H)^2}{M_a} + \frac{(qqq\ell)}{M_b^2} + \frac{(ddd\bar{\ell}H)}{M_c^3} + \frac{(\ell q\bar{d})^2}{M_d^5} + \frac{(udd)^2}{M_e^5} + \ldots$$

	ν mass	$p \to \pi^0 + e^+$	$n \to K^+ + e^-$	electron creation	$n - \bar{n}$ oscillation
L	✗	✗	✗	✗	✓
B	✓	✗	✗	✓	✗
B-L	✗	✓	✗	✗	✗

Special Issue

Neutrino Masses and Oscillations 2015

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Volume 2016 | Article ID 2162659 | https://doi.org/10.1155/2016/2162659

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Neutrinoless Double Beta Decay: 2015 Review

Stefano Dell'Oro,[1] Simone Marcocci,[1] Matteo Viel,[2,3] and **Francesco Vissani**[1,4]
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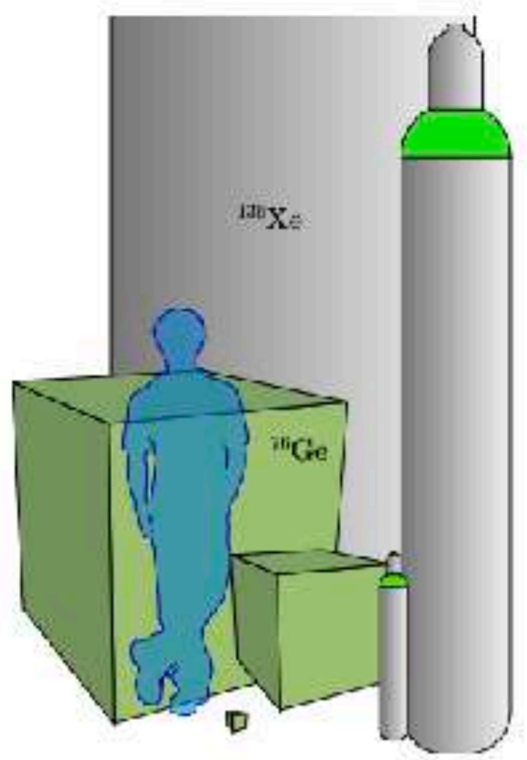


FIG. 18. Masses corresponding to present, mega and ultimate exposures, assuming zero background condition and 5 years of data acquisition. The cubes represent the amount of ^{76}Ge, the (150 bar) bottles the one of ^{136}Xe. The smallest masses depict the present exposure, while the biggest bottle is out of scale.

CONTENTS

Toward the discovery of matter creation with neutrinoless double-beta decay

Matteo Agostini*

Department of Physics and Astronomy,
University College London,
Gower Street, London WC1E 6BT,
UK

Giovanni Benato†

INFN, Laboratori Nazionali del Gran Sasso,
67100 Assergi, L'Aquila,
Italy

Jason A. Detwiler‡

Center for Experimental Nuclear Physics and Astrophysics,
and Department of Physics,
University of Washington, Seattle,
WA 98115 - USA

Javier Menéndez§

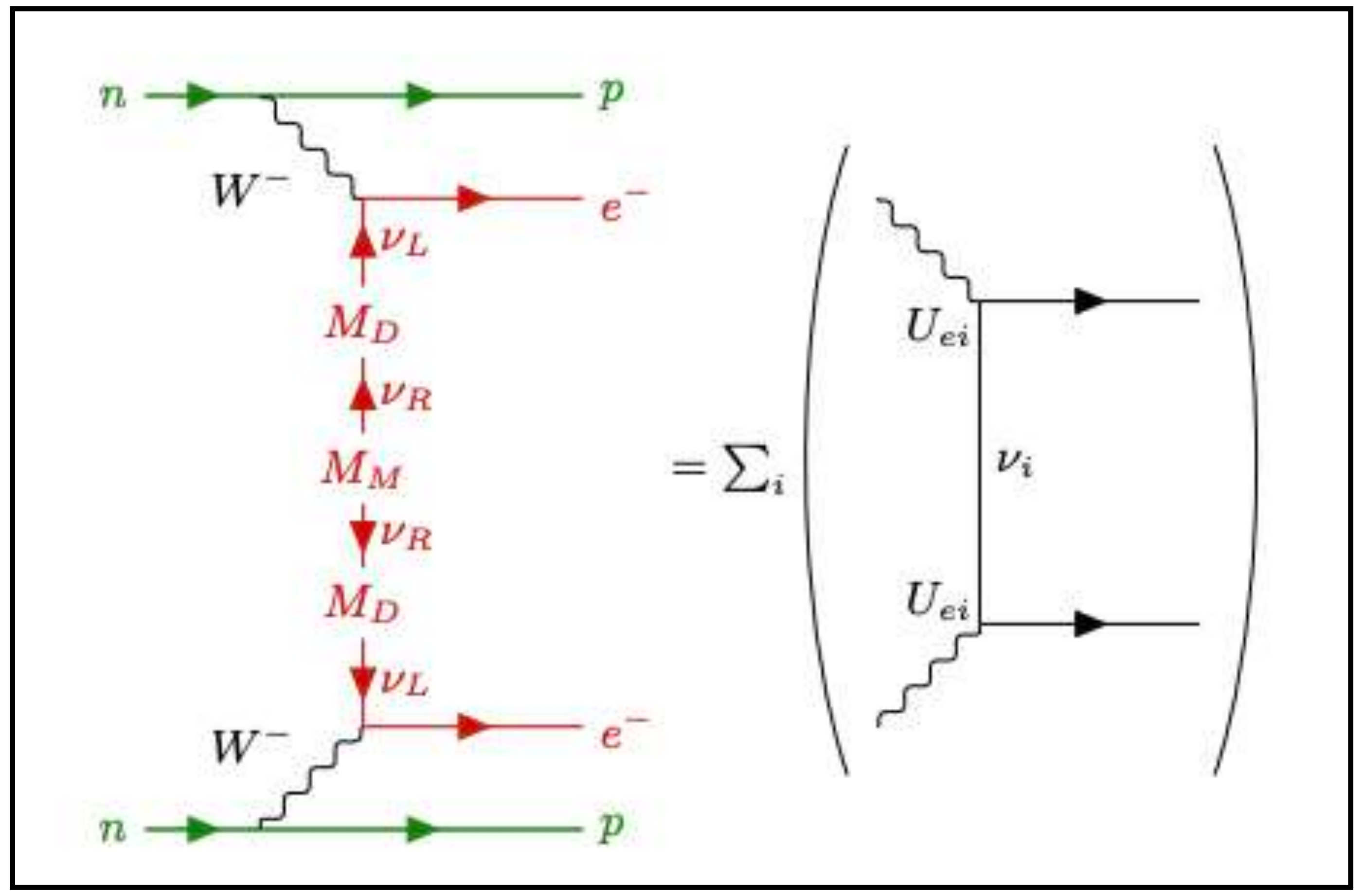
Department of Quantum Physics and Astrophysics and Institute of Cosmos Sciences,
University of Barcelona,
08028 Barcelona,
Spain

Francesco Vissani¶

INFN, Laboratori Nazionali del Gran Sasso,
67100 Assergi, L'Aquila,
Italy

(Dated: February 7, 2022)

arXiv:2202.01787v1 [hep-ex]



CONTENTS

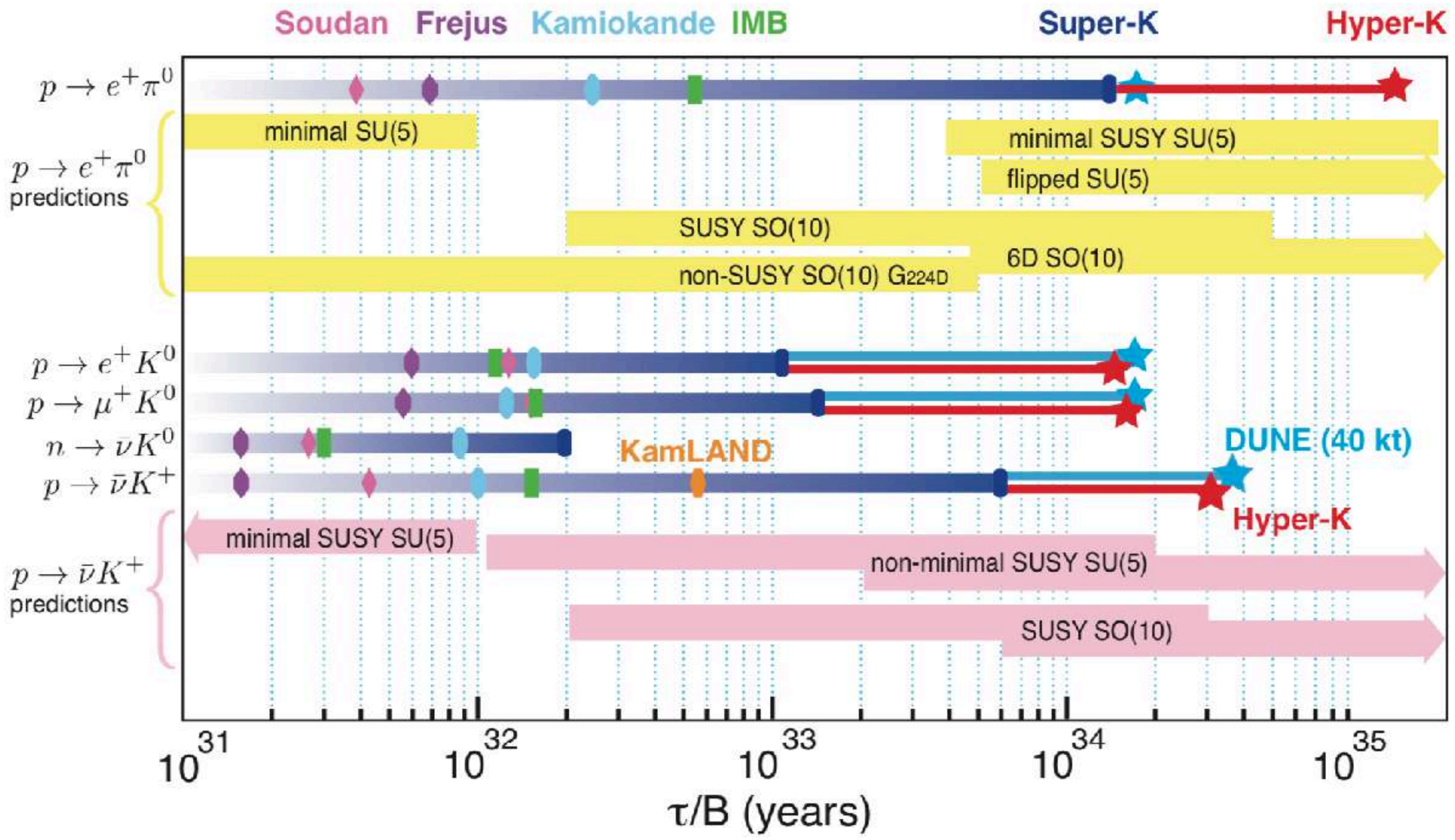
I. INTRODUCTION

In all physical processes observed so far the creation or destruction of matter is compensated by that of anti-matter. However, our universe contains an abundance of matter, a fact to which we owe our very existence. In various theories the balance of matter and antimatter can be broken, accounting for this asymmetry of our universe. At present, the most promising avenues for the detection in the laboratory of processes that alter the abundance of matter are proton decay, altering the number of baryons, and electron creation, altering the number of leptons.

The quest to observe electron creation is being pursued vigorously in the form of searches for a nuclear decay where the atomic number Z increases by two units while the nucleon number A remains constant: $(A,Z)\to(A,Z+2)+2e$. This is commonly known as "neutrinoless $\beta\beta$ decay" ($0\nu\beta\beta$ decay). Here, the creation of electrons can be enabled by the "transmutation" of neutrinos into antineutrinos, which is only possible if the neutrino has a peculiar type of mass, named after Majorana. Thus the matter-antimatter imbalance and neutrino masses could have a common origin.

A symmetry between neutrinos and antineutrinos was postulated by Majorana and further discussed by Racah in 1937. This led Furry to propose the existence of $0\nu\beta\beta$ decay in 1939, building on Goeppert Mayer's ideas on $\beta\beta$ transitions. Pioneering searches for $0\nu\beta\beta$ decay started in the 40s using time-coincidence counting techniques or visual detection of tracks in cloud chambers and photographic emulsions. Since then, experiments have

… JUNO, DUNE, HYPER-KAMIOKANDE



a 10 year anniversary

my anniversary as a coordinator

Prot. n. 0001996 del 05/09/2017 - [UOR: SI000005 - Classif. III/6]

GRAN SASSO SCIENCE INSTITUTE
SCHOOL OF ADVANCED STUDIES
Scuola Universitaria Superiore

L'Aquila, 4 Settembre 2017

Al Dr. Francesco Vissani
Sede e LNGS

Oggetto: Coordinamento dell'Area Fisica e del Dottorato in Astroparticle Physics del GSSI

Caro Francesco,

con la presente faccio seguito alla lettera del 29 Novembre 2012 (Prot.4/2012), nella quale cui ti chiedevo di ricoprire il ruolo di Coordinatore del Dottorato in Astroparticle Physics, accanto a quello dell'Area Fisica, per quattro anni (termine poi esteso senza formalità per un ulteriore anno).
In virtù della eccellente riuscita del tuo lavoro in questi anni, ti chiedo di continuare a ricoprire questi importanti ruoli anche per l'a.a. 2017/2018.

Cordialmente,

Eugenio

more anniversary: 1st publications at the GSSI

Using Low-Energy Neutrinos from Pion Decay at Rest to Probe the Proton Strangeness

Giulia Pagliaroli (Gran Sasso), Carolina Lujan-Peschard (Gran Sasso and Guanajuato U.), Manimala Mitra (Gran Sasso), Francesco Vissani (Gran Sasso and GSSI, Aquila) (Oct, 2012)

Published in: *Phys.Rev.Lett.* 111 (2013) 2, 022001 • e-Print: 1210.4225 [hep-ph]

Dark Matter Searches

F. Arneodo (Gran Sasso and GSSI, Aquila) (Jan, 2013)

Contribution to: PIC 2012, 275-286 • e-Print: 1301.0441 [astro-ph.IM]

Counting muons to probe the neutrino mass spectrum

Carolina Lujan-Peschard (Gran Sasso), Giulia Pagliaroli (Gran Sasso and Guanajuato U.), Francesco Vissani (Gran Sasso and GSSI, Aquila) (Jan, 2013)

Published in: *Eur.Phys.J.C* 73 (2013) 2439 • e-Print: 1301.4577 [hep-ph]

A millimole of muons for a Higgs Factory?

Carlo Rubbia (GSSI, Aquila) (Mar, 2013)

Contribution to: Neutel 2013

Probing Cosmic Rays in Nearby Giant Molecular Clouds with the Fermi Large Area Telescope

Rui-zhi Yang (Heidelberg, Max Planck Inst. and Purple Mountain Observ.), Emma de Oña Wilhelmi (Heidelberg, Max Planck Inst. · ICE, Bellaterra), Felix Aharonian (Heidelberg, Max Planck Inst. and Dublin Inst. and GSSI, Aquila) (Mar 29, 2013)

Published in: *Astron.Astrophys.* 566 (2014) A142 • e-Print: 1303.7323 [astro-ph.HE]

Prospects for observing and localizing gravitational-wave transients with Advanced LIGO, Advanced Virgo and KAGRA

KAGRA and LIGO Scientific and Virgo and VIRGO Collaborations • B.P. Abbott (LIGO Lab., Caltech) et al. (Apr 2, 2013)

Published in: *Living Rev.Rel.* 23 (2020) 1, 3, *Living Rev.Rel.* 21 (2018) 1, 3 • e-Print: 1304.0670 [gr-qc]

Sterile neutrinos: the necessity for a 5 sigma definitive clarification

Carlo Rubbia (GSSI, Aquila and CERN), Alberto Guglielmi (INFN, Padua), Francesco Pietropaolo (INFN, Padua), Paola Sala (INFN, Milan) (Apr 7, 2013)

e-Print: 1304.2047 [hep-ph]

The Dark Matter halo of the Milky Way, AD 2013

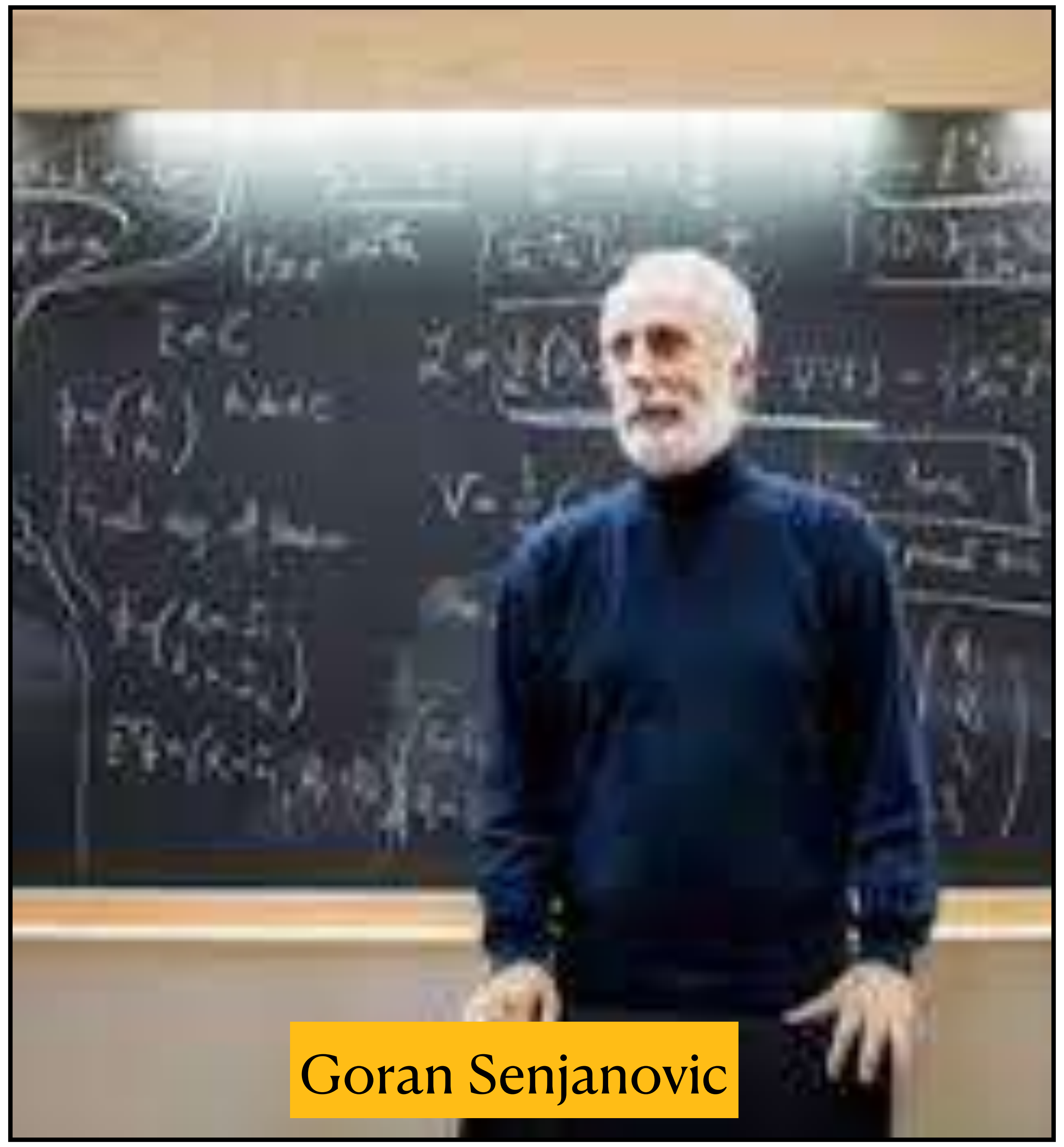
Fabrizio Nesti (GSSI, Aquila), Paolo Salucci (SISSA, Trieste) (Apr 18, 2013)

Published in: *JCAP* 07 (2013) 016 • e-Print: 1304.5127 [astro-ph.GA]

again anniversary: GSSI begins (2013-2014)

First Trimester

Introduction to Nuclear Physics	*Fiorini*
Nuclear Astrophysics	*Marcucci*
Standard Model and Extension	*Senjanović*
Neutrino Physics – Experiments	*Calaprice*
Neutrino Physics – Theory	*Vissani*
Statistics	*Caldwell*
Neutrons and Backgrounds in Underground Labs	*Kudryatsev*
Dark Matter in Astronomy and Astrophysics	*Salucci*
Aspects of Symmetry	*Iachello*
Dark Matter Theory	*Ullio*
Dark Matter Search with Scintillators	*Bernabei*
Montecarlo Methods	*Pandola*
Neutrinoless Double Beta Decay	*Cremonesi*
Dark Matter Search with Cryogenic Liquids	*Aprile*

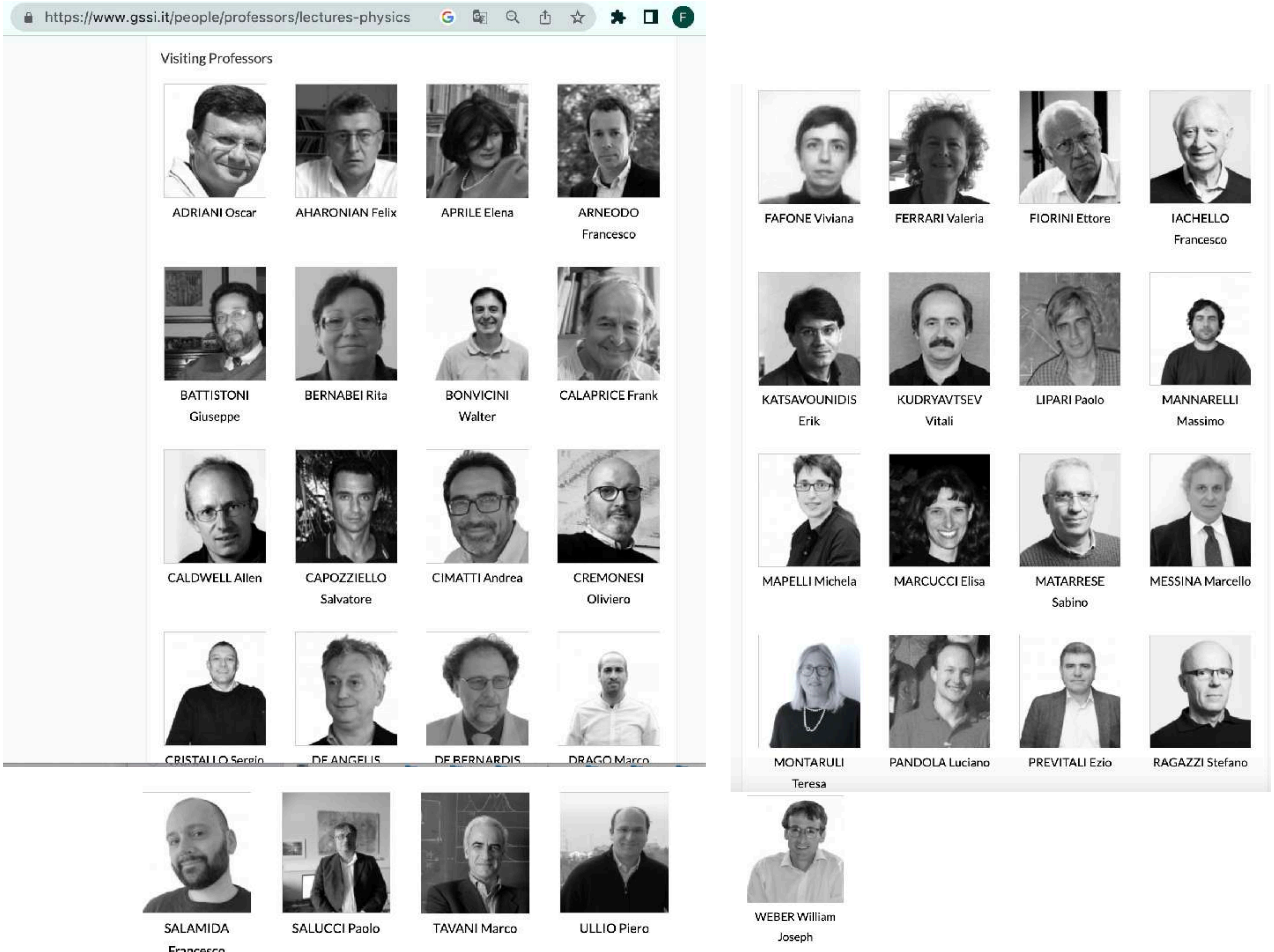


Goran Senjanovic

Second Trimester

Basics of Particle Detectors	*Petrera*
Modern Detectors	*Ragazzi*
Interactions of Hadrons at High Energy	*Battistoni*
Non-Thermal Processes in Astrophysics	*Tavani*
Physics and Astrophysics of Cosmic Rays	*Blasi*
Ultra-High Energy Cosmic Rays	*Berezinsky*
High Energy Gamma Rays	*Aharonian*
High Energy Cosmic Neutrinos	*Lipari*
General Relativity	*Capozziello*
Gravity Waves Theory – a Primer	*Schutz*
Gravity Waves Theory – Astrophysical Sources	*Ferrari*
Gravity Waves Detection – Experiments	*Fafone*
Gravity Waves Detection – Data Analysis	*Katsavounidis*
Cosmology	*Matarrese*

super anniversary

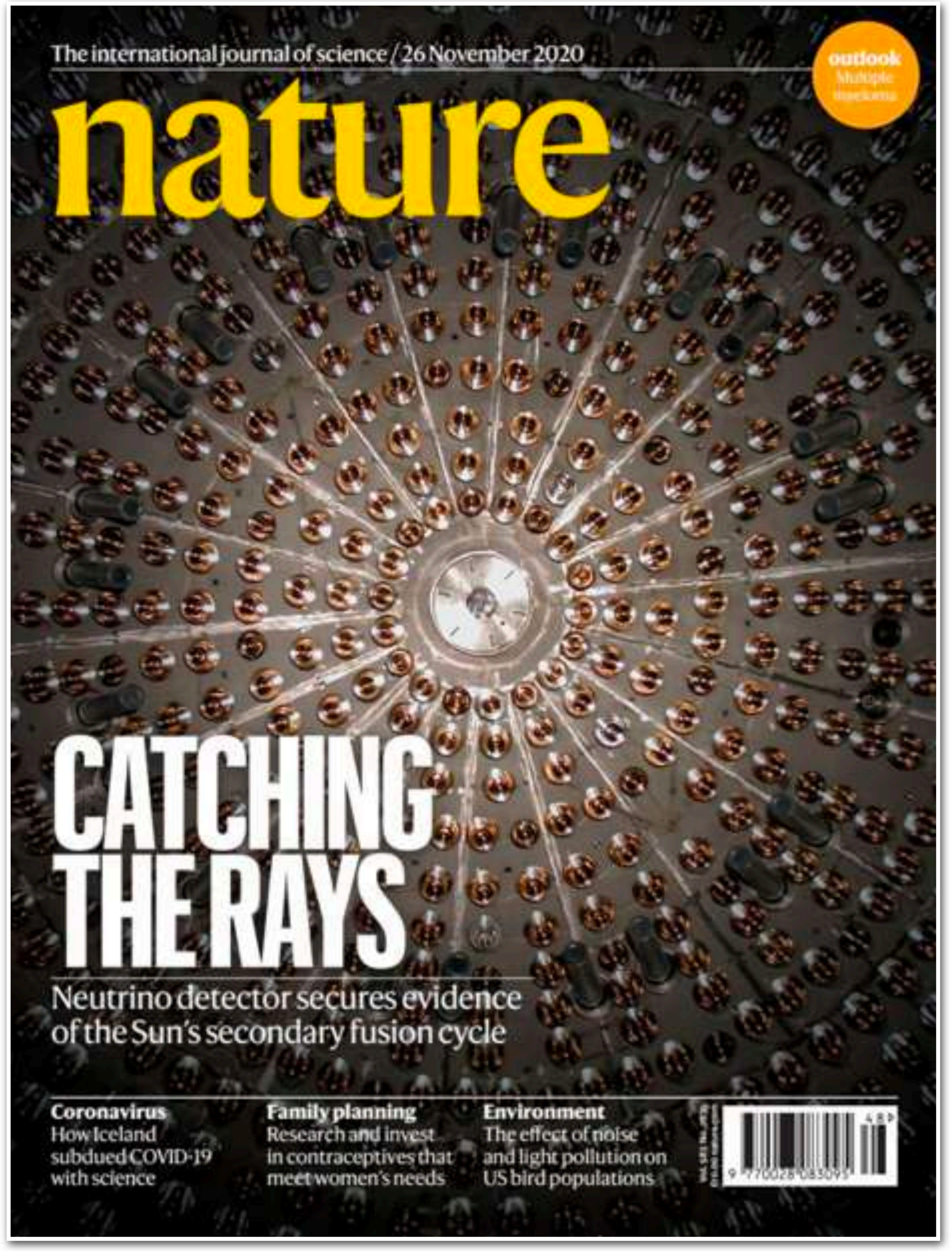


In this situation, I hope you can understand, if not excuse, my **curiosity**.

Why was my photo removed from the list of visiting professors? Is it the choice of one person or is it an expression of a shared policy?

Apart from that, I am **happy** and **honoured** to have served as a coordinator at GSSI and I am **grateful** to my colleagues who invited me today.

PhD is a great thing: my congrats and best wishes to all of you!



Thanks!