# Preface

The series of annual workshops on "What Comes Beyond the Standard Models?" started in 1998 with the idea of Norma and Holger for organizing a real workshop, in which participants would spend most of the time in discussions, confronting different approaches and ideas. Workshops take place in the picturesque town of Bled by the lake of the same name, surrounded by beautiful mountains and offering pleasant walks and mountaineering.

This year was the 20th anniversary workshop. We celebrated this by offering a talk to the general audience of Bled with the title "How far do we understand the Universe in this moment?", given by Holger Bech Frits Nielsen in the lecture hall of the Bled School of Management. The lecture hall was kindly offered by the founder of the school Danica Purg.

In our very open minded, friendly, cooperative, long, tough and demanding discussions several physicists and even some mathematicians have contributed. Most of topics presented and discussed in our Bled workshops concern the proposals how to explain physics beyond the so far accepted and experimentally confirmed both standard models — in elementary particle physics and cosmology — in order to understand the origin of assumptions of both standard models and be consequently able to make predictions for future experiments. Although most of participants are theoretical physicists, many of them with their own suggestions how to make the next step beyond the accepted models and theories, and several knowing running experiments in details, the participants from the experimental laboratories were very appreciated, helping a lot to understand what do measurements really tell and which kinds of predictions can best be tested.

The (long) presentations (with breaks and continuations over several days), followed by very detailed discussions, have been extremely useful, at least for the organizers. We hope and believe, however, that this is the case also for most of participants, including students. Many a time, namely, talks turned into very pedagogical presentations in order to clarify the assumptions and the detailed steps, analyzing the ideas, statements, proofs of statements and possible predictions, confronting participants' proposals with the proposals in the literature or with proposals of the other participants, so that all possible weak points of the proposals showed up very clearly. The ideas therefore seem to develop in these years considerably faster than they would without our workshops.

This year the gravitational waves were again confirmed, this time from two merging neutron stars — the predicted possible source of heavy elements in the universe — measured also with the for a few second delayed electromagnetic signal. Such events offer new opportunity to be explained by theories, proposed and discussed in our workshops, showing the way beyond the standard models.

This year particle physics experiments have not brought much new, although a lot of work and effort has been put in, but the news will hopefully come when further

analyses of the data gathered with 13 TeV on the LHC will be done. The analyses might show whether there are the new family to the observed three and the new scalar fields, which determine the higgs and the Yukawa couplings, as well as the heavy fifth family explaining the dark matter content, all these predicted by the spin-charge-family theory and discussed in this proceedings. Such analysis might provide a test also of the hypothesis that dark atoms, composed of new stable double charged particles, can explain the puzzling excess of slow positrons, annihilating in the center of Galaxy, as well as the excess of high energy cosmic positrons.

The new data might answer the question, whether laws of nature are elegant (as predicted by the spin-charge-family theory and also — up to the families — other Kaluza-Klein-like theories and the string theories) or "she is just using gauge groups when needed" (what many models assume, some of them with additional discrete symmetries, as in several in this proceedings).

Shall the study of Grassmann space in confrontation with Clifford space for the description of the internal degrees of freedom for fermions, discussed in this proceedings in the first and second quantization of fields, help to better understand the "elegance of the laws of nature" and consequently the laws of nature? Will the complex action including future and past, also studied in this proceedings, help? Both studies have for the working hypotheses that "all the mathematics is a part of nature". Will the assumption that "nature started" with bosons (as commuting fields) only, fermionizing bosons to obtain anti commuting fermion fields, as discussed in this proceedings, help? Might the extension of the Dirac sea to bosons (which are their own antiparticles), also presented in this proceedings, help as well to understand better the elegance of nature?

Although the supersymmetry might not be confirmed in the low energy regime, yet the regularization by higher derivatives in $N = 1$ supersymmetric gauge theories, in some cases to all the orders, might speak for the "elegance of the nature".

The fact that the spin-charge-family theory offers the explanation for all the assumptions of the standard model, predicting the symmetry $\widetilde{SU(2)} \times \widetilde{SU(2)} \times U(1)$ of mass matrices for four rather than three observed families, explaining also other phenomenas, like the dark matter existence and the matter/antimatter asymmetry (even "miraculous" cancellation of the triangle anomaly in the standard model seems natural in the spin-charge-family theory), it might very well be that there is the fourth family. New data on mixing matrices of quarks and leptons, when accurate enough, will help to determine in which interval can masses of the fourth family members be expected. There are several papers in this proceedings manifesting that the more work is put into the spin-charge-family theory the more explanations for the observed phenomena and the better theoretical grounds for this theory offers.

There are attempts in this proceedings to recognize the origin of families by guessing symmetries of the $3 \times 3$ mass matrices (this would hardly work if the $3 \times 3$ mass matrices are indeed the submatrices of the $4 \times 4$ mass matrices). There are also attempts in this proceedings to understand the appearance of families by guessing new degrees of freedom at higher energies.

The idea of compositeness of quarks and leptons are again coming back in a new context, presented in this proceedings, opening again the question whether the compositness exists at all — could such clusters be at all massless — and how far can one continue with compositness.

As every year also this year there has been not enough time to mature the very discerning and innovative discussions, for which we have spent a lot of time, into the written contributions, although some of the ideas started in previous workshops and continued through several years. Since the time to prepare the proceedings is indeed very short, less than two months, authors did not have a time to polish their contributions carefully enough, but this is compensated by the fresh content of the contributions.

Questions and answers as well as lectures enabled by M.Yu. Khlopov via Virtual Institute of Astroparticle Physics (viavca.in2p3.fr/site.html) of APC have in ample discussions helped to resolve many dilemmas. Google Analytics, showing more than 226 thousand visits to this site from 152 countries, indicates world wide interest to the problems of physics beyond the Standard models, discussed at Bled Workshop.

The reader can find the records of all the talks delivered by cosmovia since Bled 2009 on viavca.in2p3.fr/site.html in Previous - Conferences. The three talks delivered by: Norma Mankoč Borštnik (Spin-charge-family theory explains all the assumptions of the standard model, offers explanation for the dark matter, for the matter/antimatter asymmetry, explains miraculous triangle anomaly cancellation,...making several predictions), Abdelhak Djouadi (A deeper probe of new physics scenarii at the LHC) and M. Yu. Khlopov and Yu. S. Smirnov (Search for double charged particles as direct test for Dark Atom Constituents), can be accessed directly at

http://viavca.in2p3.fr/what_comes_beyond_the_standard_model_2017.html

Most of the talks can be found on the workshop homepage

http://bsm.fmf.uni-lj.si/.

Bled Workshops owe their success to participants who have at Bled in the heart of Slovene Julian Alps enabled friendly and active sharing of information and ideas, yet their success was boosted by videoconferences.

Let us conclude this preface by thanking cordially and warmly to all the participants, present personally or through the teleconferences at the Bled workshop, for their excellent presentations and in particular for really fruitful discussions and the good and friendly working atmosphere.

*Norma Mankoč Borštnik, Holger Bech Nielsen, Maxim Y. Khlopov,*
*(the Organizing comittee)*

*Norma Mankoč Borštnik, Holger Bech Nielsen, Dragan Lukman,*
*(the Editors)*

*Ljubljana, December 2017*

# 1 Predgovor (Preface in Slovenian Language)

Serija delavnic „Kako preseči oba standardna modela, kozmološkega in elektrošibkega" ("What Comes Beyond the Standard Models?") se je začela leta 1998 z idejo Norme in Holgerja, da bi organizirali delavnice, v katerih bi udeleženci v izčrpnih diskusijah kritično soočili različne ideje in teorije. Delavnicapoteka na Bledu ob slikovitem jezeru, kjer prijetni sprehodi in pohodi na čudovite gore, ki kipijo nad mestom, ponujajo priložnosti in vzpodbudo za diskusije.

To leto smo imeli jubilejno 20. delavnico. To smo proslavili s predavanjem za splošno občinstvo na Bledu z naslovom "Kako dobro razumemo naše Vesolje v tem trenutku ?", ki ga je imel Holger Bech Frits Nielsen v predavalnici IEDC (Blejska šola za management). Predavalnico nam je prijazno odstopila ustanoviteljica te šole, gospa Danica Purg.

K našim zelo odprtim, prijateljskim, dolgim in zahtevnim diskusijam, polnim iskrivega sodelovanja, je prispevalo veliko fizikov in celo nekaj matematikov. Večina predlogov teorij in modelov, predstavljenih in diskutiranih na naših Blejskih delavnicah, išče odgovore na vprašanja, ki jih v fizikalni skupnosti sprejeta in s številnimi poskusi potrjena standardni model osnovnih fermionskih in bozonskih polj ter kozmološki standardni model puščata odprta. Čeprav je večina udeležencev teoretičnih fizikov, mnogi z lastnimi idejami kako narediti naslednji korak onkraj sprejetih modelov in teorij, in tudi taki, ki poznajo zelo dobro potek poskusov, so še posebej dobrodošli predstavniki eksperimentalnih laboratorijev, ki nam pomagajo v odprtih diskusijah razjasniti resnično sporočilo meritev in ugotoviti, kakšne napovedi so potrebne, da jih lahko s poskusi dovolj zanesljivo preverijo.

Organizatorji moramo priznati, da smo se na blejskih delavnicah v (dolgih) predstavitvah (z odmori in nadaljevanji čez več dni), ki so jim sledile zelo podrobne diskusije, naučili veliko, morda več kot večina udeležencev. Upamo in verjamemo, da so veliko odnesli tudi študentje in večina udeležencev. Velikokrat so se predavanja spremenila v zelo pedagoške predstavitve, ki so pojasnile predpostavke in podrobne korake, soočile predstavljene predloge s predlogi v literaturi ali s predlogi ostalih udeležencev ter jasno pokazale, kje utegnejo tičati šibke točke predlogov. Zdi se, da so se ideje v teh letih razvijale bistveno hitreje, zahvaljujoč prav tem delavnicam.

To leto so ponovno zaznali gravitacijske valove, tokrat iz zlitja dveh nevtronskih zved — verjame se, da se pri takih pojavih tvori večina zelo težkih elementov, ki so prisotni v vesolju — kar je omogočilo spremljanje posledic zlitja tudi z elektromagnetnimi valovi. Takšni pojavi ponujajo nove možnosti za razlago s teorijami, ki jih predstavljamo in o katerih razpravljamo na naših delavnicah in kažejo pot onkraj standardnih modelov.

To leto poskusi niso prinesli veliko novega, četudi je bilo v eksperimente vloženega ogromno dela, idej in truda. Nove rezultate in z njimi nova spoznanja je pričakovati

šele, ko bodo narejene podrobnejše analize podatkov, pridobljenih na posodobljenem trkalniku (the Large Hadron Collider) pri 13 TeV. Tedaj bomo morda izvedeli ali obstajajo nova družina in nova skalarna polja, ki dolov cajo Higgsove in Yukawine sklopitve, pa tudi težka peta družina, ki razlaga temno snov (kar napoveduje teorija spinov-nabojev-družin obravnavana v več prispevkih in diskusijah v tem zborniku). Take analize bi lahko omogočile preveritev hipoteze, da obstoj temnih atomov, ki jih sestavljajo novi nabiti delci z dvojnim nabojem, lahko pojasni presežek počasnih pozitronov, ki se anihilirajo v centru Rimske Ceste in presežek kozmičnih pozitronov visokih energij.

Novi podatki bodo morda dali odgovor na vprašanje, ali so zakoni narave preprosti (kot napove teorija spinov-nabojev-družin kakor tudi — razen družin — ostale teorije Kaluza-Kleinovega tipa, pa tudi teorije strun), ali pa narava preprosto "uporabi umeritvene grupe, kadar jih potrebuje" (kar počne veliko modelov, nekateri z dodatnimi diskretnimi simetrijami, kot v tem zborniku).

Bo študij uporabe Grassmannovega prostora v namesto Cliffordovega prostora za opis vseh notranjih prostostnih stopenj fermionov ter prva in druga kvantizacija polj v vsakem od obeh prostorov, kar obravnavamo v temzborniku, pripomogla k boljšemu razumevanju "elegance naravnih zakonov" ter posledično zakonov? Bo pripomoglo k ugotovitvi, kakši so zakoni narave, proučevanje enačb gibanja, ki sledijo iz kompleksne akcije, ki vključuje preteklost in prihodnost, kar je prav tako predstavljeno v tem zborniku? Oba pristopa privzameta kot delovno hipotezo, da je "vsa matematika del narave". Ali bo pomagala predpostavka, da je "narava začela" samo z bozoni (ki so komutirajoča polja), nato fermionizirala bozone, kar je dalo antikomutirajoča fermionska polja (prav tako predstavljeno v zborniku)? Lahko razširitev Diracovega morja na bozone (ki so sami sebi antidelci), tudi predstavljena v zborniku, pomaga bolje razumeti eleganco narave?

Čeprav supersimetrije pri nizkih energijah morda ne bo opazili, lahko regularizacijo supersimetričnih umeritvenih teorij za $N = 1$, v nekaterih primerih v vseh redih, razumemo kot argument za "eleganco narave".

Dejstvo, da teorija spinov-nabojev-družin ponuja razlago predpostavk standardnega modela, napove simetrijo $\widetilde{SU(2)} \times \widetilde{SU(2)} \times U(1)$ masnih matrik za štiri družine, namesto opaženih treh družin, ter pojasni še druge pojave, kot je obstoj temne snovi in asimetrija snovi/antisnovi (celo "čudežno" odpravo trikotniške anomalije v standardnem modelu), je argument za možen obstoj četrte družine. Novi podatki o mešalnih matrikah kvarkov in leptonov bodo, če bodo dovolj natančni, pomagali določiti interval pričakovanih mas za člane četrte družine. V tem zborniku je nekaj prispevkov, ki kažejo, da z več vloženem delu ter napoveduje nove pojave.

V zborniku predstavimo tudi pristope, v katerih poskušajo pojasniti izvor družin z ugibanjem simetrij masnih matrik za tri družine (kar v primeru, da so te matrike v resnici podmatrike $3 \times 3$ matrik $4 \times 4$ ne bo dosti pomagalo). V zborniku so predstavljeni tudi poskusi, da bi razumeli pojav družin z ugibanjem novih prostostnih stopenj pri visokih energijah.

Poskusi, da bi lastnosti leptonov in kvarkov razložili kot gručo delcev, se znova pojavljajo, tokrat v zborniku v novem kontekstu, ki znova odpira vprašanje, ali so lahko takšne gruče sploh lahko (skoraj) brez mase in kako daleč lahko s podstrukturo strukture smiselno nadaljujemo.

Kot vsako leto nam tudi letos ni uspelo predstaviti v zborniku kar nekaj zelo obetavnih diskusij, ki so tekle na delavnici in za katere smo porabili veliko časa. Premalo je bilo časa do zaključka redakcije, manj kot dva meseca, zato avtorji niso mogli povsem izpiliti prispevkov, vendar upamo, da to nadomesti svežina prispevkov.
Četudi so k uspehu ,,Blejskih delavnic" največ prispevali udeleženci, ki so na Bledu omogočili prijateljsko in aktivno izmenjavo mnenj v osrčju slovenskih Julijcev, so k uspehu prispevale tudi videokonference, ki so povezale delavnice z laboratoriji po svetu. Vprašanja in odgovori ter tudi predavanja, ki jih je v zadnjih letih omogočil M.Yu. Khlopov preko Virtual Institute of Astroparticle Physics (viavca.in2p3.fr/site.html, APC, Pariz), so v izčrpnih diskusijah pomagali razčistiti marsikatero dilemo. Storitev Google Analytics pokaže več kot 226 tisoč obiskov te spletne strani iz več kot 152 držav sveta, kar kaže na širok interes v svetu za probleme fizke onkraj standardnih modelov, ki jih obravanavamo na blejskih delavnicah.
Bralec najde zapise vseh predavanj, objavljenih preko "cosmovia" od leta 2009, na viavca.in2p3.fr/site.html v povezavi Previous - Conferences. Troje letošnjih predavanj,
Norma Mankoč Borštnik (Spin-charge-family theory explains all the assumptions of the standard model, offers explanation for the dark matter, for the matter/antimatter asymmetry, explains miraculous triangle anomaly cancellation, ... making several predictions), Abdelhak Djouadi (A deeper probe of new physics scenarii at the LHC) in M. Yu. Khlopov ter Yu. S. Smirnov (Search for double charged particles as direct test for Dark Atom Constituents), je dostopnih na
http://viavca.in2p3.fr/what_comes_beyond_the_standard_model_2017.html
Večino predavanj najde bralec na spletni strani delavnice na
http://bsm.fmf.uni-lj.si/.

Naj zaključimo ta predgovor s prisrčno in toplo zahvalo vsem udeležencem, prisotnim na Bledu osebno ali preko videokonferenc, za njihova predavanja in še posebno za zelo plodne diskusije in odlično vzdušje.

*Norma Mankoč Borštnik, Holger Bech Nielsen, Maxim Y. Khlopov,*
*(Organizacijski odbor)*

*Norma Mankoč Borštnik, Holger Bech Nielsen, Dragan Lukman,*
*(uredniki)*

*Ljubljana, grudna (decembra) 2017*