

Report on the activities of the Regional Training Network in Theoretical Physics, 2013-2017

1. History

The Regional Training Network in Theoretical Physics was inaugurated on March 14, 2013 at the meeting at Tbilisi State University, Georgia. The meeting was attended by the representatives of the University of Bonn, Tbilisi State University and Yerevan State University, who have signed a MoU establishing a common doctoral program in theoretical physics. Further, under the agreement of the parties, the Regional Training Network was created as a structure which implements the provisions of the MoU in practice. At a later stage, the Network was joined by the University of Siegen, which became a signatory of the MoU as well.

The financing of the Network, to a large part, was provided by VolkswagensStiftung under the contract no. 86260. The original funding period was defined by 2,5 years, but it was granted a cost-neutral extension up to the end of September, 2017. The co-financing of the project was provided by the Universities of Tbilisi and Yerevan. For some activities, undertaken by the Network, we have managed to obtain the financial support from Rustaveli Foundation, ICTP and IOM.

The project “Regional Training Network in Theoretical Physics” was aimed at the following objectives:

- The main aim of the project was to reduce the negative impact that is caused by the brain drain in Georgia and Armenia. The massive outflow of the qualified scientific cadre leads to the worsening of the quality of the doctoral training for the young academics that, in a short term, might cause an irreversible damage to the scientific community in these countries.
- As a solution, we have proposed to fill the gaps in the doctoral education by providing advanced lecture courses held by the scientists from partner Universities. This approach may work without big investments from the Universities, because the fields of expertise of the scientists from the partner Universities differ.
- In order to allow the PhD students to have more scientific contacts at all phases of the doctoral training, we have supported co-supervision of these students by one of the senior scientists in the partner Universities.
- The doctoral schools and workshops of the Network were organized on the yearly basis. The main aim of these events was to educate doctoral students from the region in adjacent areas of physics, allowing them to widen the field of their scientific interests. World leading experts in the pertinent fields of research were chosen to deliver lectures at these schools.
- One of the main aims of the Network was to promote the mobility of the students as well as of the experienced researchers, to revive close contacts between Georgian and Armenian scientists and to establish contacts with other countries in the region as well as with German scientists from the Universities of Bonn and Siegen.
- The Universities of Bonn and Siegen were interested in attracting excellent students and young academics from the region to which, up to now, they had a little connection. They were interested in implementing a common doctoral program together with the State Universities of Tbilisi and Yerevan, that would bring the standards of doctoral education in the region closer to the European ones and thus would increase the number of highly

qualified young academics. So, from the German side, this was an investment of the resources in the future collaboration.

2. Activities between 2013-2016

(more information can be found at: <http://training.hepi.edu.ge/rtn/>)

a) Preparation and delivery of the lecture courses

In total, 23 lecture courses were prepared within the framework of the Network, and most of them are already delivered to the students of Tbilisi State University and Yerevan State University. Several lectures were transmitted via Internet by using the video devices, which were purchased through the funds provided by VolkswagenStiftung.

The full list of the lectures is given below:

- QH Skyrmions by George Tsitsishvili (winter semester 2015/2016)
- Integrable models in String-Field theory by George Jorjadze (Summer semester 2015)
- Introduction to physics of quarks with flavour and colour by Alexander Khodjamirian (Summer semester 2015)
- Introduction to Path Intergals by Akaki Rusetsky (Summer semester 2015)
- Physical Methods in Biology by Tamaz Mdzinarashvili (winter semester 2014/2015)
- Statistical Physics and Thermodynamics of Macromolecules by Yevgeni Mamasakhlisov (winter semester 2014/2015)
- Quantum Chromodynamics, part 2 by Akaki Rusetsky (Winter semester 2014/2015)
- Theory of Integrable Systems and Their Applications by David Karakhanyan (Winter semester 2014/2015)
- Basis of Two-dimensional Conformal Field Theory with Defects and Boundaries by Gor Sarkissian (Winter semester 2014/2015)
- Quantum Chromodynamics, part 1 by Akaki Rusetsky (Winter semester 2013/2014)
- Gravitation and Cosmology by Merab Gogberashvili
- Introduction to Quantum Statistical Thermodynamics by Armen Allahvedyan
- Introduction to Quantum Spin Chains by Vadim Ohanyan
- Astroparticle Physics by Revaz Shanidze, 01.04-10.05 (2014)
- Programming in PYTHON by Revaz Shanidze, 05.01-15.02 (2015)
- Astroparticle Physics by Zurab Berezhiani, 23.02-10.03 (2015)
- Solitons by Anzor Khelashvili (prepared)
- Group Theory by Tigran Hakobyan (prepared)
- Introduction to the Standard Model by Gela Devidze (prepared)
- Quantum Field Theory in a Curved Spacetime by Armen Saharian (prepared)
- Statistical Modeling and Data Analysis by Mirian Tabidze (prepared)
- Particle Physics by Vakhtang Kartvelishvili (Summer semester 2016)
- Quantum field theory in AdS Space (Higher Spins) by Ruben Manvelyan (prepared)

Note that all lecture courses delivered by the scientists from Tbilisi and Yerevan State Universities were pre-reviewed by the colleagues from the same Network. The reviewing procedure was by no means formal – in most cases, the referees requested substantial changes in the original manuscript, and there were even the cases of rejection. As a result, this procedure, which is a clear example of the quality control via the internationalization, helped to substantially improve the proposed courses, bringing them closer to the standards accepted at German Universities.

It should be pointed out that part of the lectures have been delivered by the members of the diaspora who were on short stay in their country of origin. To arrange their travel, we have attracted

resources from other sources as well. Namely, the travel of A. Rusetsky, Z. Berezhiani and R. Shanidze was financed within the IOM TRQN III program. This example clearly demonstrates that, accumulating resources from different sources in one project, one gets more effect than operating separately.

Originally, it was planned that the lecture courses could be published by the Publishing House of Tbilisi State University as well (at the moment, they are freely available at the web-page of the Network only). However, now we have decided to submit the best courses for publication to the Lecture Notes in Physics which has a much broader readership.

b) Co-supervision of doctoral students

Yerevan State University: in total, 2 Habilitation thesis, 2 PhD theses, and 5 master theses were defended since the start of the project, 3 PhD theses will be defended by the end of the project to September.

Tbilisi State University: in total, 2 PhD theses, and 3 master theses were defended since the start of the project, 1 PhD and 2 master theses will be defended by the end of year.

The PhD students that have been assigned a co-supervisor, are (only completed theses):

- Armen Saghatelian, "Action-angle variables in conformal mechanics", Supervisor Armen Nersessian (YSU), Co-supervisor Merab Gogberashvili (TSU), thesis defended at Yerevan Physics Institute 23.09.2014.
- David Mchedlishvili, "Studies of the neutron-proton charge-exchange amplitudes at COSY using the ANKE spectrometer", PhD program Advisers Hans Ströher (Fz Jülich), Andro Kacharava (Fz Jülich) and Mirian Tabidze (TSU), Supervisors Mikhael Nioradze(HEPI TSU) and Mirian Tabidze(TSU), thesis defended at Tbilisi State University 10.12.2013.
- Zara Bagdasaryan, "Measurement of nucleon-nucleon elastic scattering at small angles using the ANKE spectrometer", Ph.D program Advisers Merab Eliashvili(TSU), Mirian Tabidze (TSU) and Norair Akopov (Yerevan Physics Institute), Supervisors Nodar Lomidze (HEPI TSU) and Hans Ströher (Fz Jülich), defended at Cologne University 11.04.2016 in the Cotutelle framework.

Within this project, three students: E. Khastyan and H. Shmavonyan from Armenia, and M. Gelenava from Georgia have paid long-term exchange visits to the University of Bonn, working on their theses and attending the lectures.

c) Annual Workshops and Autumn schools

Up to now, 4 Autumn schools have been held combined with the scientific Workshops. In addition, the Network has organized, or co-organized several other scientific Workshops in Georgia and Armenia. The full list of all events can be found below:

- 2nd Workshop Quantum Aspects of Black Holes and its Recent Progress, 25-27 August, 2016, Yerevan, Armenia
- Fourth Autumn School on High Energy Physics and Quantum Field Theory, 20-23 August, 2016, Yerevan, Armenia

- Challenges in Contemporary Elementary Particles Physics and Quantum Field Theory, October 30 - November 1, 2015, Tbilisi, Georgia
- Third Autumn School & Workshop: Selected Topics in Theoretical High Energy Physics, 21-27 September, 2015, Tbilisi, Georgia
- Conference on Recent Progress in Quantum Field Theory and String Theory, 14-19 September, 2015, Yerevan, Armenia
- Supersymmetry in Integrable Systems - SIS'15, 9-13 September, 2015, Yerevan, Armenia
- Second Autumn School: High Energy Physics and Quantum Field Theory, 6-10 October, 2014, Yerevan, Armenia
- Frontiers in field and string theory, 22-26 September 2014, Yerevan
- Quantum Aspects of Black Holes and its Recent Progress, 24-26 September, 2013, Yerevan, Armenia
- The First Autumn School & Workshop: Particle Phenomenology, 23-28 September, 2013, Tbilisi, Georgia
- Inaugural Workshop of the Regional Training Network in Theoretical Physics, 14-15 March, 2013, Tbilisi, Georgia

The fifth Autumn School and Workshop of the Network will be held in Tbilisi, on September 25-30, 2017, besides ANSEF/FAR-ICTP Summer School on Theoretical Physics partially funded within current project will be held in Yerevan on August 20-27, 2017.

The number and geography of students/postdocs, participating the RTN annual schools, can be found below. The tendencies are clear:

1st RTN School, Bazaleti lake, Georgia, 2013: 7 PhD students and postdocs from Georgia, 13 from Armenia, 2 from Germany, 1 from Ukraine.

2nd RTN School, Yerevan, 2014: 13 PhD students and postdocs from Armenia, 6 from Georgia, 6 from Iran, 3 from Russia, 2 from Germany, 1 from Turkey, 1 from India.

3rd RTN School, Tbilisi, 2015: 18 PhD students and postdocs from Georgia, 7 from Armenia, 4 from Azerbaidjan, 3 from Iran, 2 from Turkey, 3 from Germany, 3 from Ukraine, 1 from Czech Republic.

4th RTN School Yerevan 2016: 12 PhD students and postdocs from Armenia, 7 Georgia, 11 from Iran, 4 from Italy, 3 from USA, 3 from Turkey, 2 from Russia, 2 from Chile, 1 from Germany, 1 from UK, 1 from Spain, 1 from Canada, 1 from France.

We consider the organization of these regular events as one of the main achievements of our Network in the first funding period. The reasons for this are the following:

- The students taking part in these events, get an unique possibility to attend the lectures and talks about the modern developments in various fields of theoretical physics, which are delivered by the well-known experts in these fields. Note that the schools and workshops,

which are held in Tbilisi and Yerevan, are usually attended by all Georgian and Armenian students working in the relevant areas. It could be barely affordable (from the financial point of view), to send such a large amount of students to the schools and workshops elsewhere in Europe or US.

- These schools and workshops have become increasingly popular at the regional scale. For example, the students from Iran, Turkey, Azerbaijan, Russia, Ukraine, Czech Republic, Italy, Chile, India, etc have attended them so far, along with the participants from Germany. We believe that our Network has a potential to become an attraction point for the theoretical physics community in the region. This was one of our main aims, as the project has started.
- These events offer a unique possibility to the doctoral students not only to learn something new in the field, but to learn each other and to build contacts with leading scientists worldwide. Note that, without holding such events directly on spot, it would be impossible to achieve a large presence of the students and senior scientists from the region, so the probability of emerging new collaborations inside the region (regional networking) would sharply diminish.
- Finally, the functioning of the Regional Training Network and, in particular, holding the schools and the workshops on the regular basis have helped to revitalize the field of theoretical physics in Georgia and Armenia – the countries that are plagued by many financial and political problems. Putting differently, these schools and workshops help to popularize the field among the undergraduate students that (hopefully) would lead to the increase of the number of those, who will eventually choose to make their doctoral thesis in theoretical physics.

d) Improving the scientific contacts of Georgian and Armenian scientists with the German colleagues, re-vitalizing the ties between Tbilisi and Yerevan, student mobility.

Prior to the start of the project, there existed no regular contacts between German scientists and their Georgian and Armenian counterparts. The same statement could be applied, to a large extent, to the contacts between the Georgian and Armenian colleagues.

The situation has changed completely after the project started. There have been regular visits of the Georgian and Armenian scientists to Germany, as well as the visits of the German participants into the region. The visits of the Georgian scientists to Armenia and vice versa have been substantially activated as well. It is worth noting that, during the regular Network Workshops, which are held each year, we have a reserved day for the Armenian-Georgian mini-workshop, which covers a broad field of topics. This is a nice opportunity for the Network participants to learn about each others' work. In other words, we would like to be a Network and not a set of groups with common interests and with almost no intersection.

It should be stressed that the young academics participating the network – first and foremost, the doctoral students – are actively involved in these contacts and exchange programs. In particular, two Armenian students and one Georgian student plan a long-term stay at the University of Bonn. The financial support for this is envisaged in the project approved by VolkswagenStiftung.

e) Implementing the e-learning concepts.

As already mentioned, part of the lecture courses have been delivered through the live videoconferencing by using the apparatus purchased with the financial help of the VolkswagenStiftung. The special lecture rooms are now available at TSU and YSU, as well as at the Universities of Bonn and Siegen.

We believe that, in the situation, when many active scientists of Georgian and Armenian origin are working at the high-ranked Universities and scientific centers worldwide, using the videoconferencing tools in the lecturing should become a routine. Georgia and Armenia do not have enough financial resources to invite lecturers from abroad during the whole semester. The same is true, e.g., for the seminar talks, student workshops, etc. For the same reason, we have insisted that all materials related to the teaching process, should be available on the web-site of the network and could be uploaded/downloaded from any location in the world.

On the other hand, we have deliberately opted for the live lectures and, in some cases, for the presence of a co-lecturer in the lecture room at TSU or YSU, who was in a direct contact with students and helped to moderate a lecture. Sometimes, we have even combined various forms of lecturing – e.g., the lecture started as a “normal” one and, after two weeks, continued via the videoconferencing. We also believe that merely recording the lectures and putting them on the web would be much less useful.

3. Summary

In the project “Regional Training Network in Theoretical Physics” we have implemented several components of the so-called structured doctoral programs. In particular, these are the concept of the continued learning (i.e., the PhD studies encompass not only the research work but the classwork as well), co-supervision of the doctoral students and the increased mobility. We also laid an accent of the internationalization of the PhD studies and the quality control through the internationalization. What is very important, the Network has attracted the researchers and students from the broader region (not only from Georgia and Armenia) that is reflected in the geography of the annual school/workshop participants.

To summarize, we feel that we have done a useful work in this project. It would be important to build on the success achieved so far, to critically re-access the bottlenecks, to analyze the mistakes and to move forward the implementing of the full-fledged structured doctoral education in Georgia and Armenia.