

# Scientific Report for ITGP – Short Visit Grant

Ilmar Gahramanov

Gothenburg, 22 March – 02 April 2014

## 1 Purpose of the visit

This is the scientific report for my visit to Chalmers University of Technology in Gothenburg, Sweden in March–April 2014. The purpose of the short visit was to continue ongoing project with Hjalmar Rosengren regarding the relationship between basic hypergeometric integrals and  $3d$  superconformal indices and possible extensions of our previous work on “pentagon identities”.

## 2 Description of the work carried out during the visit

- The work carried out during my stay in Gothenburg concerned on study supersymmetric dualities in three dimensions via superconformal index technique (for a short review, see [1]) and the relation of this subject to basic hypergeometric functions. In [2] together with Hjalmar Rosengren, using the equality of superconformal indices of mirror dual three-dimensional  $\mathcal{N} = 2$  supersymmetric theories we found the pentagon identity for the certain combination of so-called tetrahedron index which is integral identity for basic hypergeometric integrals. During the visit we mainly focused on generalizations of the pentagon identity.
- I was able to discuss our current project and related subjects and get useful comments from the members of Department of Fundamental Physics, especially from Daniel Persson.
- During the research visit I gave two seminar talks, one was on “Elliptic hypergeometric functions and Physics” and presented to mathematically oriented audience at the Department of Mathematical Sciences. The purpose of the talk was to give an idea of what one can learn about elliptic and basic hypergeometric integrals from physics. The second talk was held at the Department of Fundamental Physics entitled “Mathematical structures behind supersymmetric dualities”. In this seminar an overview on mathematical structures behind superconformal indices in various dimensions was presented to a broader audience.

## 3 Main result obtained

- The main result obtained during the visit is related to deep relationship between three-dimensional SUSY dualities and integral identities for basic hypergeometric integrals.

- Hjalmar Rosengren realized that there is a large class of basic hypergeometric integral identities (some of them he mentioned in [3]), these identities are the generalizations of the pentagon identity found in our previous work [2]. The new identities correspond to the equality of superconformal indices of s-confining theories in three dimensions. For the most part of identities, the corresponding dualities are known in the literature but the proof of these dualities using the superconformal index technique is new. Also we found some new dualities. We are currently preparing an article with Hjalmar Rosengren on these results. We expect to publish the work during this year.

## 4 Future collaboration

- We also begun a new project on related topic. We will expand on the ideas originated in [2, 3] and will study some other interesting three-dimensional dualities.

## References

- [1] I. Gahramanov and G. Vartanov, “Superconformal indices and partition functions for supersymmetric field theories,” XVIIth International Congress on Mathematical Physics pp. 695-703, [arXiv:1310.8507 [hep-th]].
- [2] I. Gahramanov and H. Rosengren, “A new pentagon identity for the tetrahedron index,” JHEP **1311**, 128 (2013) [arXiv:1309.2195 [hep-th]].
- [3] H. Rosengren, “Askey-Wilson polynomials and the tetrahedron index”, talk at Conference for Dick Askey’s 80th Birthday, 6–7 December, 2013

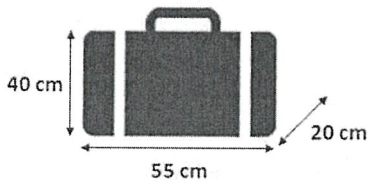


➔ Please be prepared to present your boarding pass and a personal document at the gate. Please wait until your group is called and then go to the gate immediately.

### Einsteigekarte | Boarding Pass

<b>Airline</b> airberlin	<b>Name of passenger</b> GAHRAMANOV ILMAR	<b>FQTV</b>	<b>Ticket No.</b> 7452336813676	
<b>From</b> Gothenburg-Landvetter	<b>To</b> Berlin (Tegel)	<b>Flight no.</b> AB8301	<b>Date</b> 02Apr2014	<b>Departure time</b> 19:25
	<b>Cabin Baggage</b> 1 HANDBAG + 1 ITEM	<b>Security number</b> 032	<b>Cabin Class</b> Y (FlyClassic)	
<b>Gate</b>	<b>Boarding time</b> 19:00	<b>Seat</b> 18A	<b>Boarding Group</b> B	

Gate closes 15 minutes prior departure. Please observe possible gate changes!



#### Cabin baggage

A single item of hand baggage may not exceed **8kg** and dimensions may not exceed **55x40x20cm**.



Welcome to our frequent flyer programme for infrequent flyers, too!

Register for topbonus and earn up to 1,500 welcome miles.



Promotion until 27.04.2014, only here!

More information at [airberlin.com/1500miles](http://airberlin.com/1500miles)



For telephone bookings, rebookings and questions relating to our services or for general flight information please contact the airberlin Service Centre: Telephone: 0049 30 3434 3434 (\*at local rate from a German landline; mobile phone charges in Germany u20ac 0.42/min. maximum; rates in other countries may vary.)

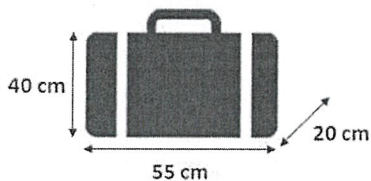


➔ Bitte halten Sie diese Einsteigekarte und ein gültiges Personaldokument beim Einsteigen bereit. Begeben Sie sich zum Einstieg, sobald Ihre Boardinggruppe aufgerufen wurde.

## Einsteigekarte | Boarding Pass

<b>Airline</b> airberlin	<b>Name of passenger</b> GAHRAMANOV ILMAR	<b>FQTV</b>	<b>Ticket No.</b> 7452336813676	
<b>From</b> Berlin (Tegel)	<b>To</b> Goeteborg-Landvetter	<b>Flight no.</b> AB8302	<b>Date</b> 23Mar2014	<b>Departure time</b> 08:55
	<b>Cabin Baggage</b> 1 HANDBAG + 1 ITEM		<b>Security number</b> 008	<b>Cabin Class</b> Y (FlyClassic)
<b>Gate</b> C43	<b>Boarding time</b> 08:30	<b>Seat</b> 12C	<b>Boarding Group</b> A	

Gate schliesst 15 Minuten vor Abflug. Bitte auf mögliche Änderungen des Flugsteiges achten!



### Handgepäck

Ein Handgepäckstück darf maximal ein Gewicht von **8 kg** aufweisen. Die Abmessungen dürfen **55x40x20cm** nicht überschreiten.



Für telefonische Buchungen, Umbuchungen und Fragen zu unseren Services oder allgemeinen Flugauskünften wenden Sie sich bitte an das airberlin Service Center: Telefon: 030 3434 3434 (zum Ortstarif); Tarife in anderen Ländern können abweichen.



Air Berlin PLC & CO. Luftverkehrs KG, Saatwinkler Damm 42-43, 13627 Berlin

ILMAR GAHRAMANOV  
GEFLUEGELSTEIG 20  
12355 BERLIN  
GERMANY

You have some questions?

You will find questions and answers on many aspects of airberlin and your booking at: [www.airberlin.com/faq](http://www.airberlin.com/faq)

## Invoice and Confirmation

06.02.2014

Page 1 / 2

### Booking details

Invoice no.	1400601857/1
Booking reference	ZJ53IA
Booking date	06.02.2014

### Passengers

1 MR ILMAR GAHRAMANOV  
2 MRS URNISA GAHRAMANOVA

### Flights

ROUTE	DATE	FLIGHT TIMES	FLIGHT
Berlin - Tegel - Gothenburg - Landvetter	23.03.2014	08:55 - 10:20	AB 8302,E Operated by Air Berlin
Gothenburg - Landvetter - Berlin - Tegel	02.04.2014	19:25 - 20:35	AB 8301,W Operated by Air Berlin

### Price details

#### Tickets

DETAILS	CURRENCY	TAX RATE	AMOUNT
<u>745-2336813676 / GAHRAMANOV/ILMAR MR</u>			
Baggage 1			
Fare	EUR	0%	15.00
<u>Taxes and fees</u>			
Fuel and security surcharge	EUR	0%	71.00
Aviation tax	EUR	0%	7.50
other taxes	EUR	0%	35.93
<u>745-2336813675 / GAHRAMANOVA/URNISA MRS</u>			
Baggage 1			
Fare	EUR	0%	15.00
<u>Taxes and fees</u>			
Fuel and security surcharge	EUR	0%	71.00
Aviation tax	EUR	0%	7.50
other taxes	EUR	0%	35.93

129

### Amount and VAT summary

DESCRIPTION	CURRENCY	AMOUNT
vatfree Amount	EUR	258.86
subject to VAT	EUR	0.00
VAT	EUR	0.00

The General Terms and Conditions of Carriage of the airberlin group apply. They are to be found on [www.airberlin.com](http://www.airberlin.com) and can be provided at all airberlin ticket counters.

Member of



Corporate Headquarters  
Berlin  
Registration  
AG Charlottenburg HRB: 23373 B  
VAT No. DE 136662780  
Creditor Identification Number  
DE31ZZ0000006880

Managing Partner  
AIR BERLIN PLC (Aktiengesellschaft englischen Rechts)  
Registered in England: Companies House, No. 5643814  
Registered Office:  
The Hour House, 32 High Street, Rickmansworth,  
Hertfordshire WD3 1ER  
Berlin branch  
Registration  
AG Charlottenburg HRB: 100000 B

Board of Directors of the PLC: Commerzbank AG Berlin  
Wolfgang Prock-Schauer, CEO BLZ 100 400 00  
Ulf Hüttmeyer, CFO Konto 217 808 500  
Paul Gregorowitsch, COO BIC COBADE33XXX  
Helmut Himmelreich, COO IBAN  
Chairman of the Board DE52100400000217808500  
Dr. Hans-Joachim Körber

Deutsche Postbank AG Berlin  
BLZ 100 100 10  
Konto 666 82 102  
BIC PBKDE33XXX  
IBAN  
DE18100100100066682102



You have some questions?

You will find questions and answers on many aspects of airberlin and your booking at: [www.airberlin.com/faq](http://www.airberlin.com/faq)

Air Berlin PLC & CO. Luftverkehrs KG, Saatwinkler Damm 42-43, 13627 Berlin

ILMAR GAHRAMANOV  
GEFLUEGELSTEIG 20  
12355 BERLIN  
GERMANY

## Invoice and Confirmation

06.02.2014

Page 2 / 2

DESCRIPTION	CURRENCY	AMOUNT
<b>Invoice Total</b>	<b>EUR</b>	<b>258.86</b>

The amounts will be charged to the following payment(s):

Direct debit	EUR	258.86
--------------	-----	--------

### Please note that all flights in this confirmation are stated in local time.

Article 26 section 3 UstG [German law on sales tax] - the cross-border carriage of persons by airlines is not subject to sales tax.

With the airberlin group you are flying ticketless. Your flight detail are saved under your invoice/confirm.no. at the checkin automatically. Please ensure that all travellers carry a valid photo ID. Please take note of the current provisions regarding hand luggage. You can find the general and special terms and conditions on the website at: [www.airberlin.com/abb](http://www.airberlin.com/abb) or at [www.flyniki.com](http://www.flyniki.com). Air Berlin PLC & Co.Luftverkehrs KG.Vat reg no.:DE 136662780 (DE transborder). Spanish branch: Gran Via Asima 6A-1°C,E-07009 Palma de Mallorca.C.I.F W-0042192E (ES) For any queries please contact our serviceteam at 0871 5000 737 (GB) or 49 (0) 30 3434 3434 seven days a week, 24 hours a day. Thank you for booking airberlin. We wish you a pleasant stay on board. Please note the current conditions of entry and residence that apply to your nationality.We would like to point out that if you are refused entry, you will have to pay for anycosts incurred (return journey to the country of departure or your home country,administrative fees etc.). Please keep your invoice and confirmation of booking with you for the trip. You may not be allowed to enter or leave the country if you do not have this document. Please note that in some countries you will need to purchase an entry visa on arrival. For further information please contact the embassy of the country of destination.

You will find full information on our fare structure at [www.airberlin.com/yourfare](http://www.airberlin.com/yourfare).

The check-in deadlines of the operating airline always apply; these are available on the Internet at [www.airberlin.com/meldeschlusszeit](http://www.airberlin.com/meldeschlusszeit). Please consult them prior to departure.

Please note: if your flight / one of your flights is operated by one of airberlin's partner airlines, you will find the special terms and conditions of transport which are applicable for the partner in question on their website or at [www.airberlin.com/codeshare](http://www.airberlin.com/codeshare).

The General Terms and Conditions of Carriage of the airberlin group apply. They are to be found on [www.airberlin.com](http://www.airberlin.com) and can be provided at all airberlin ticket counters.

Member of



Corporate Headquarters  
Berlin  
Registration  
AG Charlottenburg HRB: 23373 B  
VAT No. DE 136662780  
Creditor Identification Number  
DE312ZZ00000006980

Managing Partner  
AIR BERLIN PLC (Aktiengesellschaft englischen Rechts)  
Registered in England: Companies House, No. 5643814  
Registered Office:  
The Hour House, 32 High Street, Rickmansworth,  
Hertfordshire WD3 1ER  
Berlin branch  
Registration  
AG Charlottenburg HRB: 100000 B

Board of Directors of the PLC: Commerzbank AG Berlin  
Wolfgang Prock-Schauer, CEO BLZ 100 400 00  
Ulf Hüttmeyer, CFO Konto 217 808 500  
Paul Gregorowitsch, CCO BIC COBADE33XXX  
Helmut Himmelreich, COO IBAN  
Chairman of the Board DE52100400000217808500  
Dr. Hans-Joachim Körber

Deutsche Postbank AG Berlin  
BLZ 100 100 10  
Konto 666 82 102  
BIC PBKDE333XXX  
IBAN  
DE18100100100066682102