COSMOLOGY, THE QUANTUM VACUUM, AND ZETA FUNCtions

A WORKSHOP WITH A CELEBRATION OF EMILIO ELIZALDE'S SIXTIETH BIRTHDAY

ICE/CSIC, Universitat Autònoma de Barcelona 8-10th March, 2010

Emili Elizalde
His Life and Works
(*an Outline*)

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Universitat Politècnica de Catalunya
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Main Points

- Prelude
- Biographical notes
- Works: general outlook
  - Cosmology
  - Gravity
  - Mathematics
  - Quantum field theory
- Ending remarks

PRELUDE

SGT. PEPPERS LONELY HEARTS CLUB BAND
1967

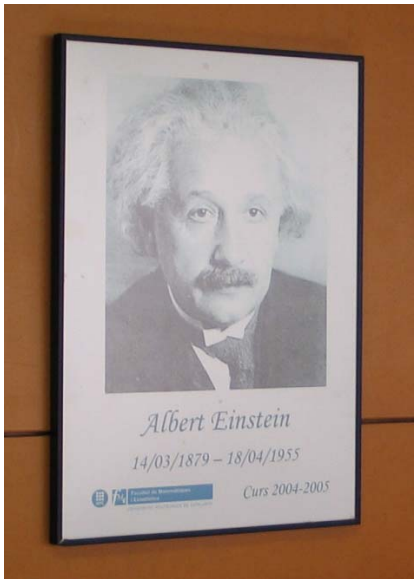
Emili used to go by unnoticed…

Take a look…

Who is this Emili that shows up in places where you would not be looking at?

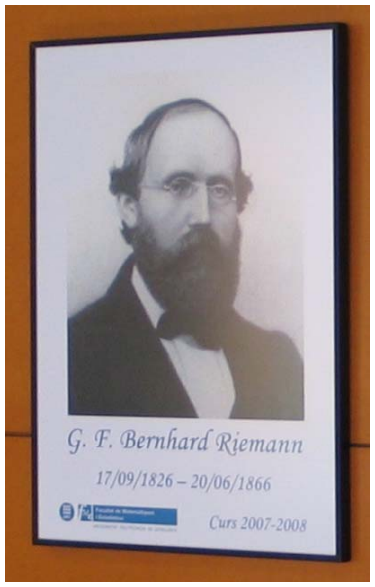
Einstein 2004-2005

On the cosmological constant, the vacuum energy, and divergent series (52 p.)




COLORS i SENSACIONS
COSMOCAIXA
TARGETA AMIGA
COSMOCAIXA
Sol·licita-la a informació
Obra Social
P

Riemann 2007-2008



Riemann and Physics (39 p.)

"The importance of the influence in Physics of Riemann's *purely mathematical* works exceeds by far that of his papers that were directly devoted to *physical* issues."

(a) The influence of Riemann's work on the *zeta function* to the *regularization of* QFT's in *curved space-time* (in particular, *quantum vacuum fluctuations*).

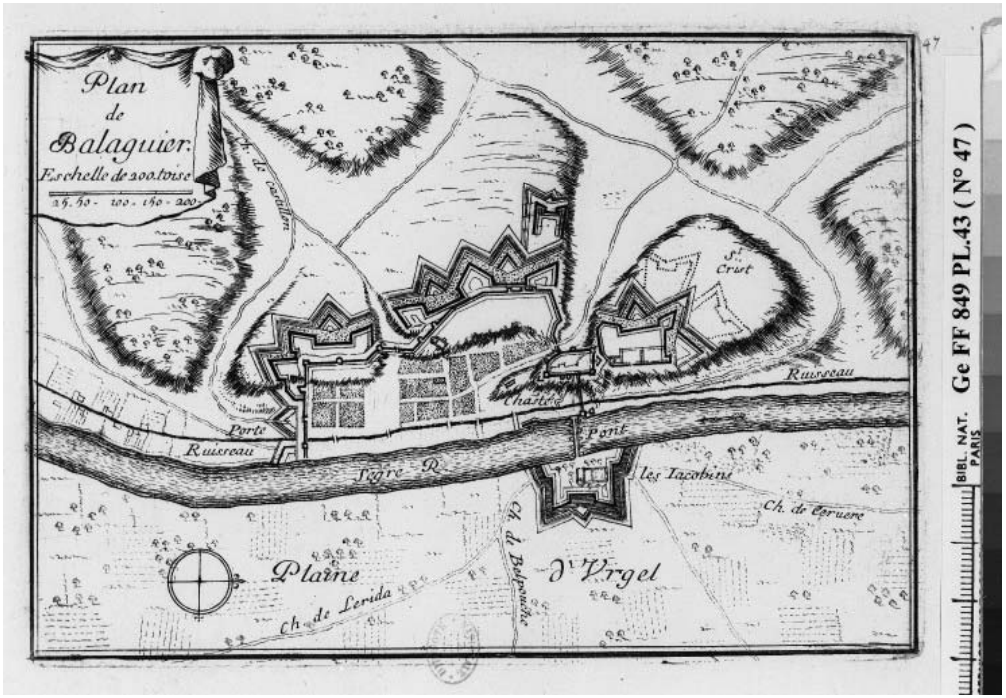
(b) The uses of the Riemann tensor in *general relativity* and in very recent generalizations of this celebrated theory, which aim at understanding the presently observed *acceleration of the universe expansion* (the *dark energy* issue).

BIOGRAPHICAL NOTES

Born 8 March 1950
(Balaguer, Lleida)

Comet cloud hypothesis (Oort)

Turing machine



Balaguer: 25 km NE of Lleida, ca 15000. Segre river.

Gaspar de Portolà i Rovira (1716-1784), explorer and founder of San Diego and Monterey.

1962 Top grade in mathematics-physics exam surprised everybody in Emili's school.
1967 Physics freshman at UB
1969 Mathematics freshman at UB

1951 21cm H radiation, predicted by Van der Hulst. Structure of our galaxy.
1953 DNA structure
1955 Galaxy explosions. Birth of new stars.
1956 Antineutrinos
1957 Sputnik. Jodrell Bank.
1958 Mössbauer effect
1959 Pound—Rebka experiment
1961 Quark eight-fold way
1963 Quasars. Arecibo radio-telescope. X-rays sources
1964 Cosmic micro-wave radiation
1967 Pulsars

1972 Physics UB
1973 ‘Master ‘ in Physics UB (advisor: P. Pascual)
1973 Mathematics UB
1976 PhD *Cum laude* in Physics (advisors: J. Gomis and P. Pascual)
First four published papers.
1976-1977 High school mathematics teacher (“catedrático”)

1968 Electroweak theory. Solar neutrinos defect.
1969 Landing on the Moon.
1970 Black-body radiation
1971 Black-body X-1 in the Swan constellation
1972 QCD
1973 Universe, a quantum fluctuation of the vacuum?
1976 Idea of cosmic strings
1977 Inflationary universe

1977 Emili and Maria Carme get married.

1977 Postdoc scholarship *Fundación Juan March*

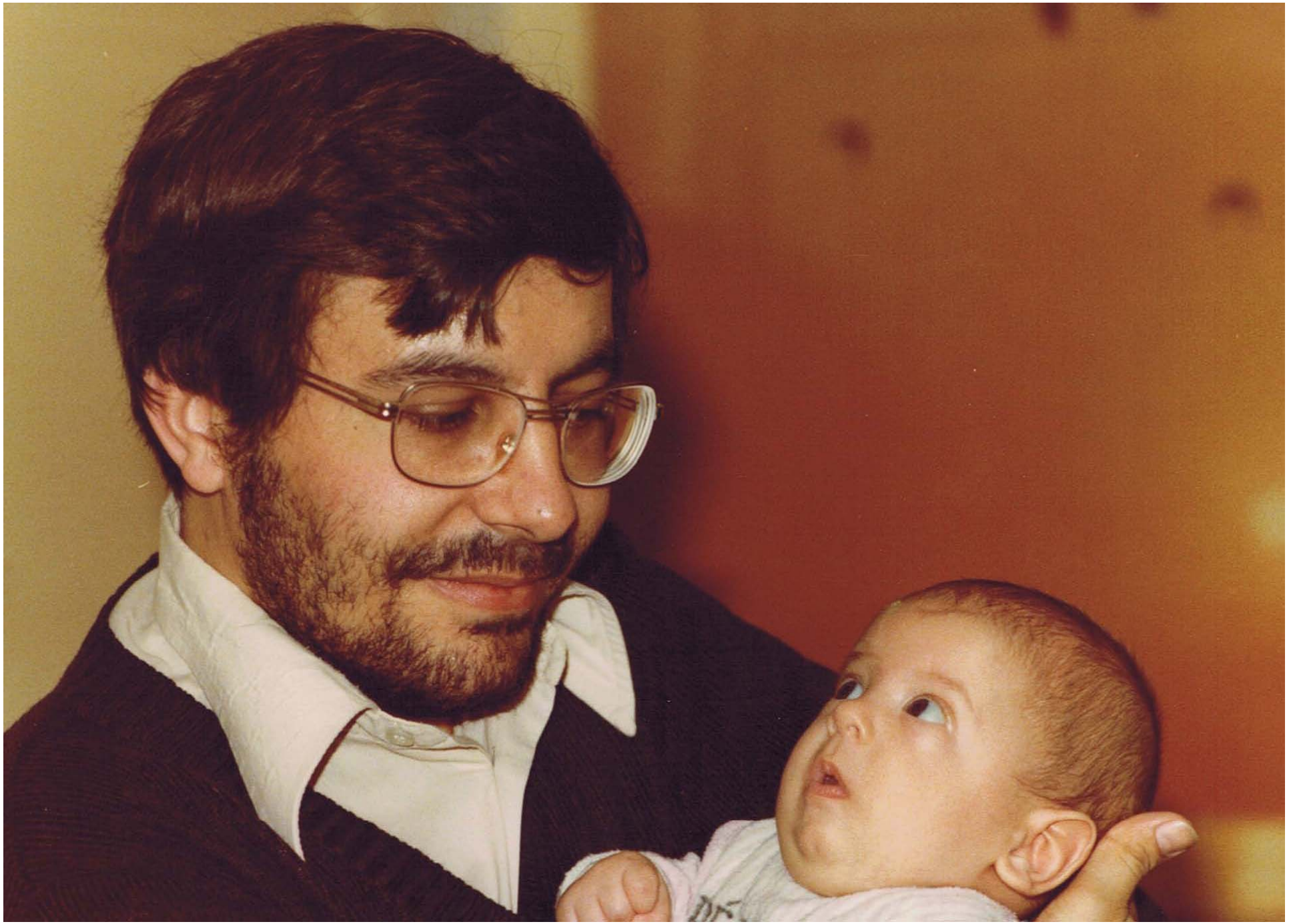
1977-1979 Fellowship *Alexander von Humboldt* (Rudolf Haag,
II. Institut für Theoretische Physik, Univ. Hamburg)
Later visits: 1981, 1985, 1987, 1989 (3 months each)

1979 Sergi

1982 Aleix

1980 Explanation of solar neutrino defect.

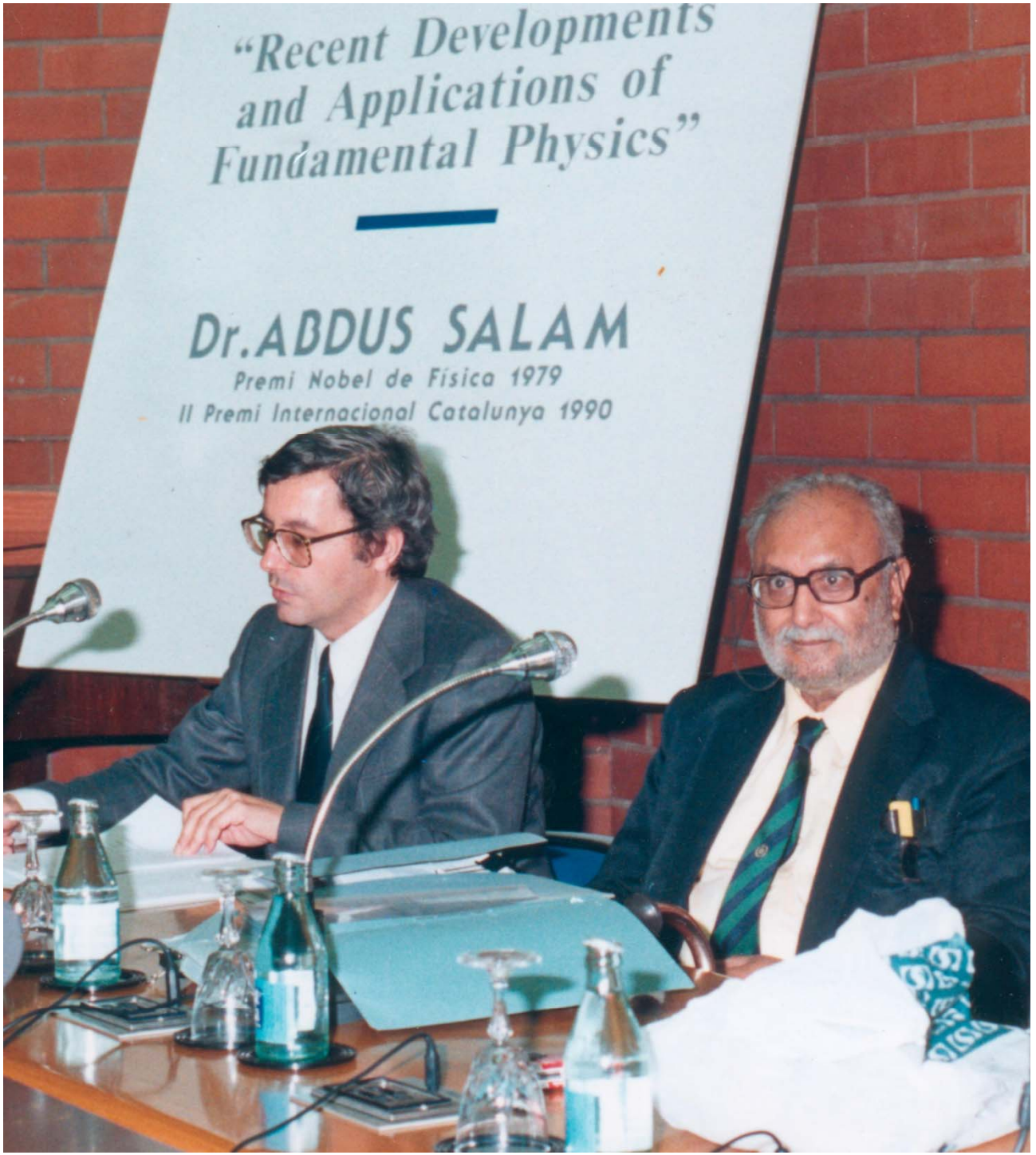
1982 Blas Cabrera: magnetic monopole?



1984 “Profesor Titular” Theoretical Physics, UB
1989 Leningrad’s Physics Institute and Dubna’s JINR (6 weeks)
1991 Pennsylvania SU, Dep of Theoretical Physics (3 months)
1992 Universities of Trondheim, Oslo and Göteborg (3 months)

1983 W^+, W^-, Z_0
1987 Supernova in the Magellanic cloud
1990 The Hubble telescope. Internet
1991 WWW
1992 Barcelona Olympiads. COBE findings on CMWR


льтет
Физико-математический
факультет
Физико-математический факультет
1 ноября 1934 г. был образован физико-математический факультет (с 15 августа 1931 г. физико-техническое отделение). Большой вклад в становление и развитие факультета внесли заслуженный деятель науки, профессор Ф.Э. Молин, профессора и доценты В.А. Малеев, М.Н. Иванов, И.И Чистяков, П.К. Рашевский, А.М. Вендеровичь, В.С. Федорова, Б.В. Казачков.
В 1980-е гг. коллектив видных физиков (Д.М. Гитман, И.В. Тютин, И.Л. Бухбиндер, П.М. Лавров, С.Д. Одинцов, В.В. Обухов, И.Л. Шапиро, Ш.М. Шварцман, В.Я.Эпп) положил начало разработке нового направления теоретической физики высоких энергий и обусловил международное сотрудничество с университетами Европы, Азии и Америки. Ныне на факультете работают 12 профессоров и 25 доцентов. Университет гордится выпускниками факультета Г.А. Псахье, А.П. Волковым, А.И. Жеравиным, Л.Э. Глоком, Я.І. Гельфман и многими другими.
NUCLEAR PHYSICS B
EFFECTIVE ACTION IN
Zeta Regularization Techniques with Applications


"Recent Developments
and Applications of
Fundamental Physics"
Dr. ABDUS SALAM
Premi Nobel de Física 1979
II Premi Internacional Catalunya 1990

1993 Scientific Researcher, CSIC
1994 Visit to Japan (4 months)
1995 European trip (4 months)
1996 Hamburg and DESY (4 months). Tata, Leipzig, …
1997 Jena and Leipzig (2 months). Viena, UNAM, Trento, …
1998 Leipzig (2 months). Trento, Jena, Paris, Prague, …
1999 Visit to MIT (3 months. Harvard, Trento, Jena, …
2000-2003 Four visits to MIT (6 weeks). Harvard, La Sapienza,
Imperial College; Athens, U-Mass, Paris; Trento, …

1993 GPS becomes operative
1994 Black hole of 3000 million solar masses in M-87. Top quark.
1995 Bose-Einstein condensate. First extra-solar planet.
1998 Acceleration of the universe expansion. Neutrino mass.
2002 Hubble estimate age of universe (13000-14000 million yrs)
2003 WMAP: 4% matter, 23% dark matter, 73% dark energy

2004 Editorial Board Journal of Physics A (IOP, London). MIT, MSRI.
2005 Fellow of the IOP. Organizer of “QFT under the Influence of External conditions.
2006 Research Project Consolider 2006-2011
2007 Editorial Board of Open Astronomy Journal.
2008 Editorial Board of Open and Particle Physics Journal, Advances in Mathematical Physics. Many invitations.
2009 Key speaker at “Andrei Sakharov 2009”

2004 First binary system of pulsars
2005 NASA X-ray observatory Chandra: huge intergallactic gas clouds, about half atoms and ions ‘lost’ afte Big Bang.
2006 Grigori Perelman awarded Fields Medal for his solution of the Poincaré conjecture.

Pilar del Castillo
Emili Elizalde

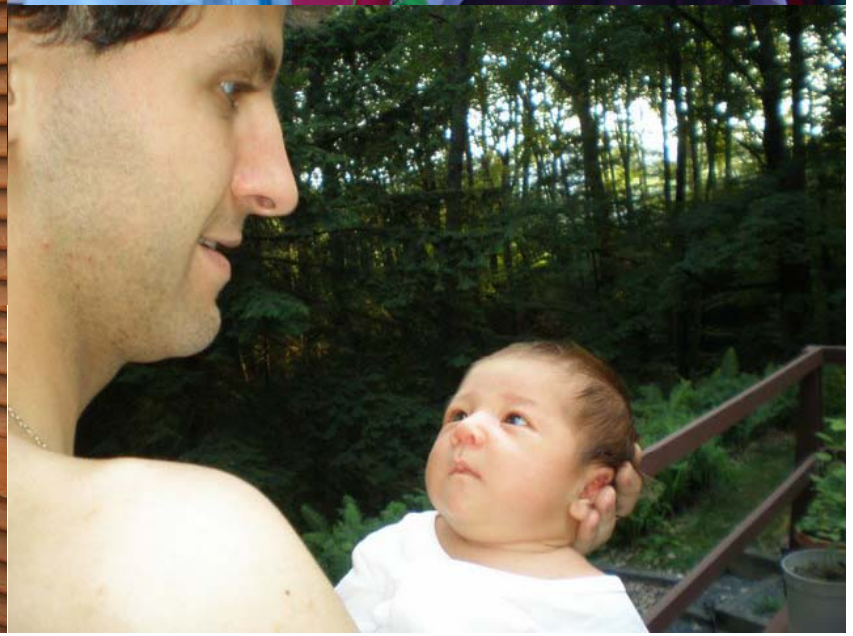
Sergi Elizalde
King Juan Carlos

Sergi's MIT Doctorhood: with parents and advisor (left).

Aleix receiving Medicine degree from UAB.

Celebrating with parents and Laia.

Musical moment



Hei-len, Seir-gi

Helen, don't make it bad,
take this guy, Sergi, and make him better,
remember to let him into your heart
then you can start to make him better.

Sergi, don't be afraid,
you were made to go out and get her,
the minute you let her under your skin
then you begin to make her better.


BARCELONA

WORKS: GENERAL OUTLOOK

Series	Description	Total
A	Papers in international journals (SCI)	235
B	Proceedings and alike	85
C	Technical notes and other articles	15
D	Books	11
E	Book chapters	9

Over 6000 citations (4500 appear in SCI).
One book with over 460 citations, another over 250
Papers with 310, 180, 170, 140, 120 and 115
More than twenty papers with over 50 citations

Areas	A	B
Cosmology	19	22
Gravity	89	25
Mathematics	57	24
Quantum Field Theory	165	72

About one third of the papers appear in more than one area.

Cosmology		
Subarea	A	B
Cosmological constant	11	13
Large scale	8	9

Gravity		
Subarea	A	B
Classical	1	0
Quantum gravity (semiclassical)	34	15
Modified gravity	19	2
Brainworlds	1	1
General relativity	17	6
String theories	17	1

Mathematics		
Subarea	A	B
General	2	0
Lie theory	8	5
Neural networks	4	1
Statistics (information theory)	11	3
Chowla-Selberg formula	1	2
Heat kernel	3	1

Quantum field theory		
Subarea	A	B
Multiplicative anomaly (dets)	22	6
Casimir effect	20	19
Curved space-time	35	11
Equations (Dirac, KG, Proca, …)	13	4
QCD	27	5
QED, neutrinos, magnetic fields	7	2
Regularization and renormalization	26	10
Vacuum energy	3	5
Yang-Mills	6	7
Quantum mechanics	6	3

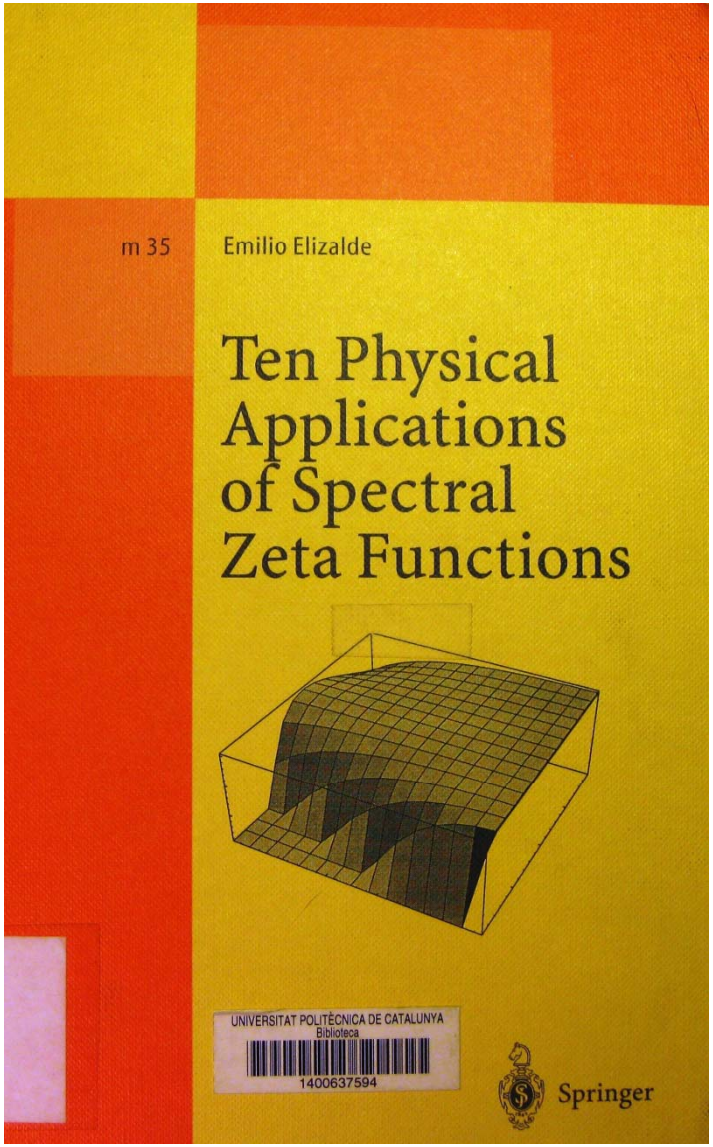
PhD Thesis		
Name	**Title**	**Year**
J. Soto	*Effective Action of QCD and the Confinement Problem*	1985
E. Gaztañaga	*Statistical Models for the Description of the Large Scale Structure of the Universe*	1989
A. Romeo	*New Aspects of Zeta Function Regularization Procedures with Incidence on QFT Vacuum Effects*	1990
S. Gómez	*Models of Learning in Artificial Neural Networks and Applications*	1994
S. Leseduarte	*Applications of the Zeta Regularization Procedure in Quantum Field Theory*	1996
P. Fosalba*	*Cosmological Perturbation Theory and the Spherical Collapse Model*	1998
S. R. Hildebrandt*	*Kerr-Schild and Generalized Metric Groups, with some Applications to Regularized Black Holes*	2001
J. Barriga*	*Mathematical Analysis of Microwave Density Fluctuations*	2002
M.Tierz	*Random Matrix Models in Chern-Simons Theory*	2008
* Co-advisor.		

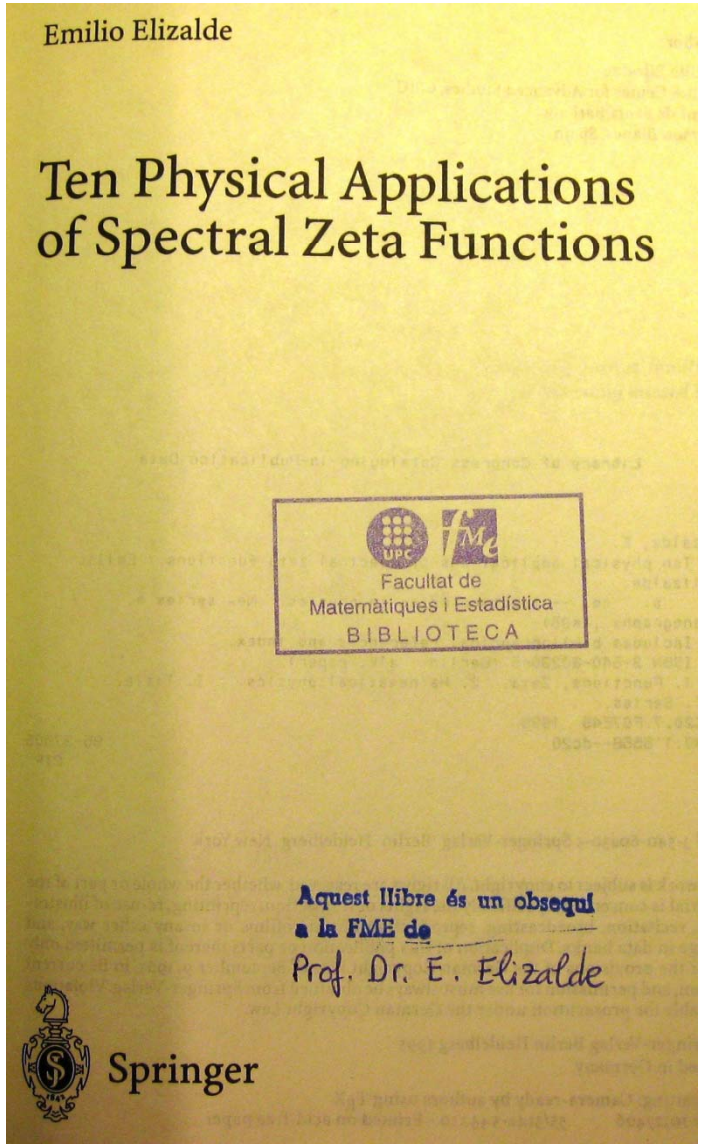
	Statistics						
	0	**1**	**2**	**3**	**4**	**5**	
A	51	80	62	31	9	2	**235**
B	40	22	12	7	5	0	**86**
C	8	7	2	3	1	1	**22**
D	7	1	2	0	2	0	**12**
E	12	1	1	0	0	0	**14**
	118	**111**	**79**	**41**	**17**	**3**	**369**

Collaborators		
Name	A	B
Sergei Odintsov	82	21
August Romeo	29	6
Sergio Zerbini	22	4
Sin’ichi Nojiri	17	1
Guido Cognola	15	5
Andrei Bytsenko, Klaus Kirsten	10	1, 5
Enrique Gaztañaga	9	4
Segei Naftulin	8	4
J. Haro	7	0
Leseduarte, Yuri Shil’nov	6	1, 6
Gomis, Hildebrandt, Soto	5	0, 2, 1

ENDING REMARKS

"Invitation to plunge into the thrilling world of zeta functions and their applications in physics"





E. Elizalde, S.D. Odintsov, A. Romeo, A.A. Bytsenko and S. Zerbini:
Zeta regularization techniques with applications.
World Scientific, Singapore, 1994. (> 460 cit)

E. Elizalde: *Ten physical applications of spectral zeta functions*
Lecture Notes in Physics. Springer-Verlag, Berlin, 1995. (> 250 cit)

A second volume? A new edition?

Emili‘s Home Page

Emili:

Happy Birthday!

Per molts anys!!