BRÅKET

Information om seminarier och högre undervisning i matematiska ämnen i Stockholmsområdet

NR 31 **FREDAGEN DEN 6 OKTOBER 2000**

BRÅKET

Veckobladet från Institutionen för matematik vid Kungl Tekniska Högskolan och Matematiska institutionen vid Stockholms universitet

Redaktör: Gunnar Karlsson

Telefon: 08-790 84 79

Adress för e-post: gunnark@math.kth.se

Bråket på Internet: http://www.math.kth.se/braaket.html eller http://www.math.kth.se/braket/

Postadress:
Red. för Bråket
Institutionen för matematik
KTH
100 44 Stockholm

- - - - - - -

Sista manustid för nästa nummer:
Torsdagen den 12 oktober kl. 13.00.

Minisymposium on Integral Quadratic Constraints

Detta äger rum på KTH fredagen den 6 oktober. Se sidorna 6 – 7.

Quadratic Relations

En konferens med detta namn äger rum på SU under tiden 13 – 16 oktober. Se sidan 8.

SEMINARIER

Fr 10 – 06 **kl. 9.00 – 10.00. Kollokvium i fysik. Docent Anders Karlsson,** Kvantelektronik och kvantoptik, KTH, Kista: *Quantum cryptography; are we now moving from promise to practice?* Sal F01, Fysiska institutionen, KTH, Lindstedtsvägen 24, b.v. Se Bråket nr 30 sidan 11.

Fr 10 – 06 **kl. 11.00 – 12.00. Optimization and Systems Theory Seminar. Professor Anders Rantzer,** Lunds tekniska högskola: *On stability and convergence of nonlinear systems.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se sidan 9.

Fr 10 – 06 **kl. 13.15. Seminar in Mathematical Physics. Marek Gozdz:** *Dirac operator on a fuzzy 3-sphere.* (Presentation of Master Thesis.) Seminarierummet, Teoretisk fysik, KTH, Osquldas väg 6, plan 4.

Fr 10 – 06 **kl. 13.30. Minisymposium on Integral Quadratic Constraints. Vladimir Yakubovich,** St. Petersburg University: *Quadratic criterion for absolute stability of nonlinear periodic systems and related topics.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se sidan 6.

Observera att schemat för minisymposiet har ändrats. Se sidorna 6 – 7.

Fortsättning på nästa sida.

Kurser

Dževad Belkić: The Principles and Methods of Quantum Scattering Theory. Se sidorna 11 – 18.

Alexander Shen: Kolmogorov Complexity and its Applications. Se sidan 5.

Money, jobs: Se sidorna 9 – 10.

Seminarier (fortsättning)

Fr 10–06 kl. 14.30. Minisymposium on Integral Quadratic Constraints. Anton Shiriaev, Odense University: *Stability of systems via integral quadratic constraints.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se Bråket nr 30 sidan 10.

Fr 10–06 kl. 15.30. Minisymposium on Integral Quadratic Constraints. Anders Hansson, Reglerteknik, S3, KTH: *Efficient solution of linear matrix inequalities for integral quadratic constraints.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se Bråket nr 30 sidan 10.

Fr 10–06 kl. 16.00. Minisymposium on Integral Quadratic Constraints. Alexandre Megretski, Massachusetts Institute of Technology: *Integral quadratic constraints in automated system analysis.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se Bråket nr 30 sidan 11.

Må 10–09 kl. 13.15 – 15.00. Algebra and Geometry Seminar. Jan-Erik Roos: *New homological properties of ring maps.* Rum 306, hus 6, Matematiska institutionen, SU, Kräftriket, Roslagsvägen 101. Se sidan 4.

Må 10–09 kl. 15.15 – 17.00. Seminarium i matematisk statistik. Lars Holst: *Om tangent-, Euler- och Bernoullital.* Seminarierum 3733, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se Bråket nr 30 sidan 4.

Ti 10–10 kl. 10.15. Plurikomplexa seminariet. Stanislav Smirnov: *On some problems of Littlewood.* Sal MIC 2215, Matematiska institutionen, Polacksbacken, Uppsala universitet. Se sidan 5.

Ti 10–10 kl. 13.15. Licentiatseminarium i matematik och **Plurikomplexa seminariet. Thomas Ernst** presenterar sin licentiatavhandling: *The history of q-calculus and a new method.* (Uppsala universitet, Matematiska institutionen, rapport 2000:16.) Inbjuden diskutant: **Jet Wimp,** Drexel University, Philadelphia. Sal MIC 2344, Matematiska institutionen, Polacksbacken, Uppsala universitet.

Ti 10–10 kl. 14.00 – 15.00. Mittag-Leffler Seminar. Yi Zhang, Istanbul: *Adjoining cofinitary permutations.* Institut Mittag-Leffler, Auravägen 17, Djursholm.

Ti 10–10 kl. 15.00 – 16.00. Artinian Gorenstein rings and Frobenius algebras. Dan Laksov: *Basic theory of Frobenius algebras, part IV.* Sammanträdesrum 3548, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 5.

Ti 10–10 kl. 16.15 – 17.15. Alexei Gorodentsev, Independent University of Moscow: *Abelian Lagrangian algebraic geometry.* Sammanträdesrum 3548, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 5. Se sidan 4.

On 10–11 kl. 13.00. Licentiatseminarium i statistik. *(Observera lokalen!)* **Christian Tallberg** framlägger sin licentiatavhandling: *Centrality and Random Graphs.* Opponent: **Professor Peter J. Carrington,** University of Waterloo, Canada. Sal B413, Södra huset, Frescati, Universitetsvägen 10 B, 4 vån. Se Bråket nr 30 sidan 5.

On 10–11 kl. 13.15 – 15.00. Seminarium i analys och dynamiska system. Professor Vadim Kaimanovich, Rennes: *Asymptotical properties of Markov operators.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se sidan 7.

On 10–11 kl. 13.15 – 15.00. Seminar on stacks. Torsten Ekedahl. Fortsättning från seminariet den 4 oktober. Rum 321, Matematiska institutionen, SU, Kräftriket, Roslagsvägen 101. Se Bråket nr 30 sidan 4.

Fortsättning på nästa sida.

Seminarier (fortsättning)

On 10–11 kl. 14.00 – 15.00. Mittag-Leffler Seminar. John Steel, Berkeley: *Core model theory.* Institut Mittag-Leffler, Auravägen 17, Djursholm.

On 10–11 kl. 15.15 – 16.00. Seminarium i matematik och fysik vid Mälardalens högskola (Västerås). Erling Englund, Umeå universitet: *Perturbed renewal equations with applications to queueing systems and risk processes.* Rum N13, Mälardalens högskola, Högskoleplan, Västerås. Internet-adressen till information om seminariet är http://www.ima.mdh.se/_seminars.htm.

On 10–11 kl. 15.30 – 16.30. Mittag-Leffler Seminar. Andreas Blass, Ann Arbor: *Divisibility of Dedekind-finite sets.* Institut Mittag-Leffler, Auravägen 17, Djursholm.

To 10–12 kl. 15.15 – 17.00. Professor Paul Cohen, Stanford: *Lecture on Analytic Number Theory.* (Det femte föredraget i en serie.) Sal C1, Electrum, Kista. Se Bråket nr 26 sidan 4 och Bråket nr 30 sidan 9.

To 10–12 kl. 15.15 – 17.00. Kombinatorikseminarium. Volkmar Welker, University of Marburg: *Local cohomology of Stanley-Reisner rings with support in monomial ideals.* Seminarierum 3733, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se sidan 7.

To 10–12 kl. 16.30. Doktorandseminarium i matematisk statistik. Annica Dominicus, SU: *Statistiska problem i tvillingstudier.* Rum 306, Cramérrummet, hus 6, Matematiska institutionen, SU, Kräftriket, Roslagsvägen 101.

Fr 10–13 kl. 9.00 – 10.00. Kollokvium i fysik. Speaker to be announced: *The Nobel Prize in Physics 2000.* Sal F01, Fysiska institutionen, KTH, Lindstedtsvägen 24, b.v.

Fr 10–13 kl. 11.00 – 12.00. Optimization and Systems Theory Seminar. Dr Ilya Ioslovich, Faculty of Agricultural Engineering, Technion, Haifa, Israel: *Upper bounds for duals of positive linear programs with box-constrained uncertainties.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se Bråket nr 30 sidan 4.

Fr 10–13 kl. 13.00. Docentföreläsning i matematik. Benjamin Baumslag: *Subgroups of groups with a finite presentation: A sketch of some important results in combinatorial group theory.* Seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se Bråket nr 30 sidan 4.

Må 10–16 kl. 15.15 – 16.00. Seminarium i matematisk statistik. Torbjörn Uddevik presenterar sitt examensarbete: *Trading rules for dynamic liability management.* Seminarierum 3733, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7. Se sidan 8.

On 10–18 kl. 13.00. Seminarium i statistik. Dr Marinus Spreen, Maastricht University, Nederländerna: *On drug abusers and networks.* Rum B705, Statistiska institutionen, SU.

On 10–18 kl. 15.15 – 16.00. Seminarium i matematik och fysik vid Mälardalens högskola (Västerås). Richard Bonner, Institutionen för matematik och fysik vid Mälardalens högskola: *Computational nature of economic decision.* Rum N24, Mälardalens högskola, Högskoleplan, Västerås. Internet-adressen till information om seminariet är http://www.ima.mdh.se/_seminars.htm.

To 10–19 kl. 10.30. Waveletseminarium. Tatiana Levitina, gästforskare vid Avdelningen för kvantkemi, Uppsala universitet. *Title to be announced.* Lokal meddelas i nästa nummer av Bråket.

Fortsättning på nästa sida.

Seminarier (fortsättning)

To 10–19 kl. 15.15 – 17.00. Professor Paul Cohen, Stanford: *Lecture on Analytic Number Theory.* (Det sjätte föredraget i en serie.) Sal C1, Electrum, Kista. Se Bråket nr 26 sidan 4 och Bråket nr 30 sidan 9.

Fr 10–20 kl. 9.00 – 10.00. Kollokvium i fysik. Professor Lars Bergström, Fysikum, SU: *Matter and energy in the universe.* Sal F01, Fysiska institutionen, KTH, Lindstedtsvägen 24, b.v. Se sidan 7.

ALGEBRA AND GEOMETRY SEMINAR

Jan-Erik Roos: New homological properties of ring maps

Abstract: Let R and S be two rings and consider a ring map $\rho\colon R \to S$. One usually connects the homological properties of R and S by means of a change of rings spectral sequence (or something slightly more sophisticated — one example is the Avramov spectral sequence if R and S are local rings). However, not even in the case when R is a Koszul algebra (will be defined) do these spectral sequences have nice properties in general.

In the talk I will study a method (which in the case when R and S are Koszul algebras was suggested by L. Positselskij) of comparing the so-called Koszul complex (will be defined) $R^* \otimes R^!$ of R and the similar complex for S. This will lead to a nicer theory. This last assertion will be supported by many examples.

Tid och plats: Måndagen den 9 oktober kl. 13.15 – 15.00 i rum 306, hus 6, Matematiska institutionen, SU, Kräftriket, Roslagsvägen 101.

SEMINARIUM

Alexei Gorodentsev: Abelian Lagrangian algebraic geometry

Abstract: This is a report on joint work with A. N. Tyurin, available via http from Max-Planck-Institute preprint server as MPI-2000-7.

Starting with any smooth symplectic manifold M, ω equipped with prequantization data, that is a Hermitean line bundle L with a Hermitean connection a whose curvature form is proportional to ω, we construct an infinite-dimensional Kähler manifold $\mathcal{B}_t^{\mathrm{hw}}$, of half weighted Bohr-Sommerfeld cycles of fixed volume t on M. This $\mathcal{B}_t^{\mathrm{hw}}$ is coming with holomorphic prequantization data on itself (in particular, it is ready to be quantized again). If some complex structure on M, ω is fixed in such a way that ω turns to its Kähler form and L becomes holomorphic, then we construct “almost” holomorphic maps $\mathcal{B}_t^{\mathrm{hw}} \to \mathbb{P}H^0(M, L)$, to the projective space of global holomorphic sections of L, which is the space of states for the Kählerian geometric quantization procedure. So, all the geometry of Kähler quantization (which depends on the complex structure choice on M) is induced by the universal projective geometry of the infinite-dimensional projective variety $\mathcal{B}_t^{\mathrm{hw}}$.

If time allows, some examples, conjectures, and open questions will be discussed as well.

Tid och plats: Tisdagen den 10 oktober kl. 16.15 – 17.15 i sammanträdesrum 3548, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 5.

PLURIKOMPLEXA SEMINARIET

Stanislav Smirnov: On some problems of Littlewood

Abstract: We shall discuss a connection between a few problems studied by Littlewood. They include finding the growth rate for the length of Green's lines (electrostatic equipotentials), decay rate for coefficients of bounded univalent functions, and bounds for area integrals of the spherical derivative of polynomials.

Tid och plats: Tisdagen den 10 oktober kl. 10.15 i sal MIC 2215, Matematiska institutionen, Polacksbacken, Uppsala universitet.

COURSE IN UPPSALA

Alexander Shen: Kolmogorov Complexity and its Applications

During the weeks 44 – 50 (October 30 – December 15, 2000) *Professor Alexander Shen* from Moscow University and Moscow Independent University will give a course on *Kolmogorov Complexity and its Applications* at the Department of Computing Science of Uppsala University.

In Uppsala this course (worth 5 p) is suggested to 3rd year DVP (Computer Science Program) students, 3rd and 4th year MNP (Mathematics and Natural Sciences) students, and graduate students.

There will be two lectures per week, on Monday afternoons (13.15 – 15.00) and Thursday mornings (10.15 – 12.00). The first lecture is scheduled for Monday, October 30, 2000.

The course will cover Kolmogorov complexity and algorithmic information theory. We use the theory of algorithms to define the complexity of an individual string (instead of random variables as in Shannon information theory) and the notion of individual random object.

Plan:

- Kolmogorov complexity: basic definitions.
- Conditional complexity and its properties.
- Random sequences.
- Prefix complexity and a priori probability.
- Monotone complexity and other complexities.
- Complexity and randomness.
- Random sequences and probability theory.
- Shannon entropy and Kolmogorov complexity.
- Frequency approach to randomness.
- Kolmogorov complexity and combinatorial inequalities.

The plan is tentative; the contents of the course will depend on the interests of the participants.

Recommended book: Ming Li, Paul Vitanyi, *An Introduction to Kolmogorov Complexity and its Applications.* Second Edition, Springer-Verlag, 1997.

Please visit the web page http://www.csd.uu.se/~vorobyov/Courses/KC/2000/ for regular updates about the course.

MINISYMPOSIUM ON INTEGRAL QUADRATIC CONSTRAINTS

This minisymposium is organized by the Division of Optimization and Systems Theory, KTH. The purpose is to bring together leading researchers to discuss the current status of the field.

It will take place on Friday, October 6, 2000, in seminar room 3721, Department of Mathematics, KTH, Lindstedtsvägen 25, floor 7.

The notion *integral quadratic constraint* was introduced by Yakubovich in the 1960's, and it has been shown to be a useful concept in systems analysis. Indeed, it unifies much of the existing stability theory, and it results in stability criteria that can be verified using convex optimization.

There will be four presentations, each followed by a discussion. The schedule given on pages 10 – 11 in Bråket no. 30 has been altered and is no longer valid. Therefore a new schedule is given.

Schedule

13.30 **Vladimir Yakubovich:** *Quadratic criterion for absolute stability of nonlinear periodic systems and related topics.*

The theory of absolute stability was pioneered by A. I. Lur'e in the fifties and is now well-developed. Its main results are the sufficient frequency domain conditions for global stability of nonlinear (or linear nonstationary) systems with a stationary linear part. These conditions are uniform for a certain class of nonlinearities, described explicitly. These criteria can also be considered as stability criteria of uncertain systems, studied in last years. In the sixties, the author obtained a general "quadratic criterion" for absolute stability. This criterion deals with a class of systems, described by a fixed linear stationary block and a finite set of integral quadratic constraints. The constraints replace the nonlinear (or linear nonstationary) blocks. The criterion transforms these integral quadratic constraints into a frequency domain sufficient condition for absolute stability. Many known results, as well as many new results, were obtained in this way. Recently A. Megretski and A. Rantzer extended this criterion to a new class of integral quadratic constraints, and the author established that the quadratic criterion is not only sufficient but also necessary for absolute stability.

The talk is devoted to similar results for systems with a periodically nonstationary linear part. Several years ago a similar quadratic criterion was obtained by the author as a sufficient condition for absolute stability. Now it becomes clear that it is also necessary. The periodic case is much richer than the stationary one. In this criterion, an essentially new oscillatority condition appears together with the frequency domain condition. We will speak very briefly on the connections with other areas of mathematics (such as Pontryagin's maximum principle, linear-quadratic optimization problems for periodic plant equations, stability and instability domains in the functional space Hamiltonians, oscillatority of linear Hamiltonian systems, the existence of the Lyapunov function, the parametric resonance).

14.30 **Anton Shiriaev:** *Stability of systems via integral quadratic constraints.*

Abstract: see Bråket no. 30 page 10.

15.00 Coffee break.

15.30 **Anders Hansson:** *Efficient solution of linear matrix inequalities for integral quadratic constraints.*

Abstract: see Bråket no. 30 page 10.

(Continued on the next page.)

16.00 **Alexandre Megretski:** *Integral quadratic constraints in automated system analysis.* Abstract: see Bråket no. 30 page 11.

17.00 Discussion.

18.00 End of the symposium.

SEMINARIUM I ANALYS OCH DYNAMISKA SYSTEM

Vadim Kaimanovich: Asymptotical properties of Markov operators

Abstract: Random walks on groups and Brownian motion on manifolds give rise to various notions characterizing their behaviour at infinity: harmonic functions, harmonic measure, the Poisson formula, entropy, rate of escape, etc. The talk is devoted to a discussion of these notions and their connection with classical counterparts from harmonic analysis and theory of dynamical systems.

Tid och plats: Onsdagen den 11 oktober kl. 13.15 – 15.00 i seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7.

KOMBINATORIKSEMINARIUM

Volkmar Welker: Local cohomology of Stanley-Reisner rings with support in monomial ideals

Abstract: For a pair (Δ, Σ) of simplicial complexes the Stanley-Reisner ideal I_Σ of Σ contains the one of Δ. Thus if J is the image of I_Σ in the Stanley-Reisner ring $k[\Delta]$ then the local cohomology modules $H^i_J(k[\Delta])$ are well-defined. We give a topological formula for the local cohomology modules (extending formulas by Hochster in case $\Sigma = \emptyset$ and, Mustasa and Tarai for Δ being the full simplex). Using this formula we analyse the structure of the local cohomology and interpret well-known results from commutative algebra (e.g. Hartshorne-Lichtenbaum vanishing theorem) topologically. Other results concern the local cohomology of the canonical modules of $k[\Delta]$ with respect to J in case Δ is CM.

This is joint work with V. Reiner and K. Yanagawa.

Seminariets hemsida: http://www.math.kth.se/~kozlov/seminar.html.

Tid och plats: Torsdagen den 12 oktober kl. 15.15 – 17.00 i seminarierum 3733, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7.

KOLLOKVIUM I FYSIK

Lars Bergström: Matter and energy in the universe

Abstract: Recent results from supernova cosmology and the cosmic microwave background have caused a revision of the basic parameters of the standard cosmological model. This will be reviewed, and some intriguing aspects of the new results connected to dark matter and dark energy (including Einstein's famous cosmological constant) will be discussed.

Tid och plats: Fredagen den 20 oktober kl. 9.00 – 10.00 i sal F01, Fysiska institutionen, KTH, Lindstedtsvägen 24, b.v.

QUADRATIC RELATIONS

The conference *Quadratic Relations* will take place at the Department of Mathematics, Stockholm University, from Friday, October 13, to Monday, October 16.

Schedule

Friday, October 13

9.00 – 9.45	**Steve Halperin:** *Some survey.*
10.00 – 10.45	**Mike Stillman:** *Local equations of the toric Hilbert Scheme.*
11.15 – 12.00	**Jürgen Herzog:** *Homological properties of Rees rings.*
14.00 – 14.45	**Aldo Conca:** *Koszul algebras and cubic forms.*
15.00 – 15.45	**Volkmar Welker:** *Discrete Morse theory for cellular resolutions.*
16.15 – 16.35	**Gert Almkvist:** *The chromatic polynomial is a Hilbert polynomial.*

Saturday, October 14

9.00 – 9.45	**Jan-Erik Roos:** *To be announced.*
10.00 – 10.45	**Kathryn Hess:** *Hochschild and cyclic homology of cocommutative Hopf algebras.*
11.15 – 12.00	**Hans Baues:** *Quadratic endofunctors of the category of groups.*
14.00 – 14.45	**Iena Peeva:** *To be announced.*
15.00 – 15.45	**Larry Lambe:** *To be announced.*
16.15 – 17.00	**Luchezar Avramov:** *Finite regularity and Koszul algebras.*

Monday, October 16

9.00 – 9.45	**Idun Reiten:** *Hereditary categories.*
10.00 – 10.20	**Victor Ufnarovski:** *Gröbner bases, resolutions and coalgebras.*
10.20 – 10.45	**Gustaf Lindencrona, President of the University.**
11.15 – 12.00	**Arnfinn Laudal:** *Non-commutative algebraic geometry and invariant theory.*
14.00 – 14.45	**Ragnar Buchweitz:** *Hochschild cohomology, Atiyah classes and the centre of the derived category.*
15.00 – 15.45	**Askar Dzhumadildaev:** *Novikov algebras, Arnold algebras and Leibniz algebras.*
16.15 – 17.00	**Leonid Positselski:** *Koszul duality for DG modules.*

SEMINARIUM I MATEMATISK STATISTIK

Torbjörn Uddevik

presenterar sitt examensarbete:

Trading rules for dynamic liability management

Abstract: The thesis presents and evaluates two specific methods where the objective is to find an economically credible generic active investment strategy that outperforms a static benchmark strategy.

Firstly, we use a regression approach to determine the factors that explain bond returns and to increase our understanding of the market. From this we form simple generic trading rules that are consistent with the previous experience.

Secondly, we present a trading rule that captures value from the mean reversion of interest rates and explore it in theory and practice.

Tid och plats: Måndagen den 16 oktober kl. 15.15 – 16.00 i seminarierum 3733, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7.

OPTIMIZATION AND SYSTEMS THEORY SEMINAR

Anders Rantzer:

On stability and convergence of nonlinear systems

Abstract: Lyapunov's second theorem is a standard tool for stability analysis of nonlinear ordinary differential equations. In this lecture, we discuss a theorem which can be viewed as a dual to Lyapunov's result. Assuming existence of a scalar function satisfying certain inequalities, it is possible to prove that "almost all trajectories" of the system tend to zero.

The scalar function has a physical interpretation as the stationary density of a substance that is generated in all points of the state space and flows along the system trajectories. If the stationary density is bounded everywhere except at a singularity in the origin, then almost all trajectories tend towards the origin.

The weaker notion of stability allows for applications also in situations where Lyapunov's theorem cannot be used. Moreover, the use of density functions has advantages in control theory, for the synthesis of stabilizing controllers. These issues will be addressed in the seminar, and the relation between density functions and Lyapunov functions will be further explained.

Tid och plats: Fredagen den 6 oktober kl. 11.00 – 12.00 i seminarierum 3721, Institutionen för matematik, KTH, Lindstedtsvägen 25, plan 7.

MONEY, JOBS

Columnist: Pär Holm, Department of Mathematics, SU. E-mail: pho@matematik.su.se.

Info = information. This will be given and repeated until obsolete. Rely on other sources as well.

BBKTH = Bulletin Board at the Department of Mathematics, KTH.

BBSU = Bulletin Board at the Department of Mathematics, SU.

Unless stated otherwise, a given date is the last date (e.g. for applications), and the year is 2000. A number without an explanation is a telephone number.

Standard information channels

1. A channel to information from TFR: http://www.tfr.se.
2. A channel to information from NFR: http://www.nfr.se.
3. A channel to information from the European Mathematical Society: http://www.emis.de.
4. A channel to information from the American Mathematical Society: http://www.ams.org.
5. KTH site for information on funds, etc., weekly: http://www.admin.kth.se/info/kth-kalendern/stipendier.html.
6. Stockholm University site for information on funds: http://apple.datakom.su.se/stipendier/.
7. Umeå site for information on funds: http://www.umu.se/umu/aktuellt/stipendier_fond_anslag.html.
8. Job announcement site: http://www.maths.lth.se/nordic/Euro-Math-Job.html. This is run by the European Mathematical Society.
9. KTH site for information on research: http://www.admin.kth.se/CA/extrel/index/forsk.html.

New information

Jobs, to apply for

10. Institutionen för lärarutbildning vid Luleå tekniska universitet söker en universitetsadjunkt i matematik, 18 oktober. Info: Nils Erik Lindell, 0920 - 915 27, Nils-Erik.Lindell@lh.luth.se, eller Kerstin Näsberg, 0920 - 915 54, Kerstin.Nasberg@lh.luth.se. Web-info: http://www.luth.se/new/vacancy/univadjmat.html.

(Continued on the next page.)

11. Institutionerna för fysik, matematik och mekanik vid KTH söker en doktorand, finansierad av medel från Göran Gustafssons stiftelse, 23 oktober. Info: Arne Johnson, 08-16 11 03, eller Anna Brising, 08-790 65 12. Web-info: http://web.kth.se/aktuellt/tjanster/Anst/Dokt_GG.html.
12. Umeå universitet söker en forskningsassistent/provkonstruktör i matematik för projektet Nationella prov (NP), 25 oktober. Info: Jan-Olof Lindström, 090-786 66 57, eller Märta Granberg, 090-786 56 26. Web-info: http://www.umu.se/umu/aktuellt/arkiv/lediga_tjanster/3125-1804-1805-00.html.

Old information

Money, to apply for

13. Kungliga Vetenskapsakademien (KVA) utlyser följande stipendier och anslag inom bl.a. matematik:

    Postdoc-stipendier för ett till två års vistelse i Japan, Israel eller Sydafrika. 1 november.

    Anslag för projektsamarbete mellan forskare i Sverige och länderna inom f.d. Sovjetunionen. 15 februari 2001.

    Anslag för projektsamarbete med forskare i Polen, Storbritannien, Tjeckien eller Ungern. 26 februari 2001.

    Forskarutbyte för vistelse två till åtta veckor i Estland, Lettland eller Litauen; två veckor till sex månader i Japan, Kina eller Ryssland, eller högst två veckor i Österrike. 1 november.

    Info: 08-673 95 00, stipendier@kva.se. Web-info: http://www.kva.se/sve/pg/int_samarbete/utbyte/index.asp.
14. Stiftelsen för internationalisering av högre utbildning och forskning (STINT) utlyser bidrag för kortare utlandsvistelser för lärare eller forskare vid svenskt universitet, högskola eller forskningsinstitut, dock ej doktorander. Ansökan kan inlämnas fortlöpande under året, dock senast 8 veckor före den dag då utlandsvistelsen avses påbörjas. Web-info: http://www.stint.se/KPutlys.html.
15. Anslag ställs, från Knut och Alice Wallenbergs Stiftelse, till rektors för KTH förfogande för att ”i första hand användas till bidrag för sådana resor, som bäst befordrar ett personligt vetenskapligt utbyte till gagn för svensk forskning. Bidrag skall främst beviljas till yngre forskare.” Ansökan om resebidrag skall ställas till rektors kansli. Bidrag kan sökas när som helst under året. Info: se punkt 5 ovan.
16. Nordisk Forskerutdanningsakademi (NorFA) finansierar nordiskt samarbete inom forskning och forskarutbildning genom dels personliga stipendier (mobilitetsstipendier och för deltagande i nationella forskarutbildningskurser), dels anslag till institutioner (forskarutbildningskurser, nordiska nätverk, gästprofessurer och workshops). Info: http://www.norfa.no.
17. Svenska Institutet (SI) utlyser kontinuerligt stipendier och bidrag för studier och forskning utomlands: stipendier för Europastudier, internationella forskarstipendier, Östersjöstipendier, Visbyprogrammet, m.m. Aktuell information om SI:s samtliga stipendiemöjligheter och ansökningshandlingar finns på SI:s hemsida: http://www.si.se.
18. Stiftelsen för internationalisering av högre utbildning och forskning (STINT) utlyser medel för att främja samarbete med universitet och högskolor i Republiken Korea (Sydkorea), Taiwan, Hongkong, Indonesien och Egypten. Ansökningar skall inlämnas minst 6 – 8 veckor före verksamhetsstarten, och medlen kan sökas löpande under året. Info: STINT, Skeppargatan 8, 114 52 Stockholm, 08-662 76 90. Web-info: www.stint.se.
19. Wenner-Gren Stiftelserna utlyser gästföreläsaranslag, avsedda att möjliggöra för svenska forskare eller institutioner att inbjuda utländska gästföreläsare. Anslag sökes av den inbjudande forskaren eller institutionen. Ansökan kan inlämnas när som helst under året. Web-info: http://www.swgc.org/.
20. NUTEK stipends for stay in research institutions (not universities) in Japan. Short or long periods. For persons with or almost with doctoral degree. Info: Kurt Borgne, 08-681 92 65, kurt.borgne@nutek.se. You can apply at any time.

Jobs, to apply for

21. Matematiska och systemtekniska institutionen vid Växjö universitet söker en universitetslektor/-adjunkt, med 50 % i matematikdidaktik, 9 oktober. Info: Jörgen Fors, 0470-70 86 28, eller Mathias Hedenborg, 0470-70 86 38. Web-info: http://www.vxu.se/jobb/universitetslektor_matematikdidaktik_001009.html.
22. Matematikcentrum vid Lunds universitet söker en doktorand i matematisk statistik med inriktning mot miljöstatistik, 11 oktober. Info: Ulla Holst, 046-222 85 49, Ulla.Holst@matstat.lu.se. Web-info: http://www2.lth.se/ledjobb/dokt/index.asp.

GRADUATE COURSE

Dževad Belkić: The Principles and Methods of Quantum Scattering Theory

Dževad Belkić is Guest Professor in "Mathematical Radiation Physics" at Karolinska Institutet, Stockholm.

The credit of the course is 5 p. It is given on one day per week (Monday) from January 22, 2001, to March 19, 2001.

The course is given at the Department of Physics, KTH, in room F01, Lindstedtsvägen 24.

Literature: A textbook by DŽEVAD BELKIĆ, *The Principles and Methods of Quantum Scattering Theory,* Institute of Physics Publishing Ltd. (Bristol, England), to appear in March 2001 [ISNP 075030496] (http://bookmark.iop.org/bookpge.htm?ID=617983879-6410-59741210-D&book=493h).

Description of the course

The most important physical aspects of quantum mechanics are *interactions* in bound systems and predictions relevant to particle *scatterings.* In the first theme, an especially important place is reserved for properties of energy levels of certain compact, isolated physical systems, e.g. elementary particles, atoms, ions, molecules, i.e., some general particles including photons. The other type of research problems describe collisions among these general particles, as one of the most universal methods for investigating the structure of matter. These latter problems are the subject of our concern in this course.

Modern quantum scattering theory is built on the Green and Møller operators. Their proper introduction is directly responsible for *unitarity* of the scattering S-matrix, which contains the entire physical information about the system under study. Such a general and versatile methodologic concept, which guarantees probability conservation, largely surpasses the frames of scattering theory. This is because an entirely similar concept is also encountered in field theory, solid state physics, plasma and atomic physics, classical mechanics, as well as in mechanics of continual media. That is why the S-matrix formalism is chosen to be the main issue in the present course. This quantity unifies all the individually studied fields of scattering theory, irrespective of whether we are dealing with a general analysis of principles and concepts or with concrete physical phenomena.

The role of the S-matrix, as one of the most fundamental quantities of quantum mechanics, is examined both rigorously and simply from the standpoint of formal scattering theory. In the time evolution of collision systems, one inevitably encouters the problem of the so-called asymptotic freedom of scattering systems. This special freedom is comprised of the natural physical requirement that the wave packets of scattering states, the evolution of which is governed by the examined potential ($V \neq 0$), coincide before and after collision with the corresponding wave packets generated beyond the reach of the given interaction field ($V = 0$). Tremendous conceptual and practical difficulties with the peculiar Coulomb potentials are thoroughly illuminated. The genuine physical content of the principles as well as the major methods of quantum scattering theory for radiative and radiationless transitions are illustrated in several branches of physics, such as field theory, solid state physics, plasma physics, atomic, molecular and optical physics. Emphasis is placed onto highly correlated scattering events involving particles, antiparticles and photons.

A unified theoretical treatment of collisions and spectroscopy will be thoroughly analysed by means of the auto- and cross-correlation functions within signal processing. Moreover, this versatile concept is abstract in the sense that the auto-correlation functions are independent of their origin and, therefore, could be generated either theoretically or measured

(Continued on the next page.)

experimentally as time signals. In either case, the auto-correlation functions physically represent the instantaneous *survival probability* of the corresponding time-dependent state of the studied system. This has far-reaching consequences since, on the one hand, experimental time signal points can be used directly, without any reference to the theory, to deduce by *computations* the basic observables for scattering and spectroscopy, such as cross sections, rate coefficients, etc. On the other hand, the experimental time signals, that are also identifiable as counts per channels, can be directly and dynamically intertwined with the theory on a much more fundamental level than what has been done thus far. This offers new opportunities relative to a traditional, quite 'static' relationship between theory and experiment, restricted mainly to comparisons between measured and calculated observables 'integrated' or 'averaged' over some important 'inner' degrees of freedom. We intercept such 'integrations' or 'averaging' and use the 'non-edited', i.e., raw experimental time signals to essentially provide *new experimental results* with a much higher resolving power *by means* of the theory.

Crucially, we redesign the concept of the very experiment and intervene on the fundamental level on the spectrometer's resolution. This avenue has not been customarily touched upon by the theory, since one does not usually consider experimental, intrinsic resolution as a potential subject for the theory. However, the existing experimental resolution power is already limited by a particular theory, which is the Fast Fourier Transform (FFT), commercially built into every spectrometer. The latter method can and should be complemented whenever necessary by other more powerful high-resolution nonlinear parametric estimators that are able to extract, directly from the measurements without any post-processing fits, the main spectral features, i.e., information about resonances. The most attractive method is the Fast Padé Transform (FPT) with its unique set of virtues and, in particular, the least effort invested in computations to efficiently arrive at the highest possible resolution and the optimal signal-to-noise ratio; {Belkić, *N. Instr. Meth. B.* **154** (1999) 220}: [*1*], {Belkić, Dando, Main, Taylor, *Chem. Phys. Lett.* **315** (1999) 135, *J. Chem. Phys.* **113** (2000) 6542, *Europhys. Lett.* **48** (1999) 250, *J. Phys. A.* **33** (2000) 1247}: [*2*]. Essential to this success of FPT is the dimensionality reduction of the original 'large data matrix' problem, and this can be effectively accomplished either without [*1*] or with [*2*], a special kind of windowing called 'band-limited decimation'. In both cases, Refs. [*1*] and [*2*], we obtain the unprecedented improvement in the *experimental* resolution power itself using solely this novel *theoretical* parametric estimator, which can be built into a given spectrometer much in the same fashion as FFT. Our theory is an interface to new experiments in scattering and spectroscopy with the possibility of reaching a substantially higher experimental resolution power than the one currently available. This was most strikingly demonstrated in ion-cyclotron resonance (ICR) mass spectroscopy and nuclear magnetic resonance (NMR), where we essentially suggest supplementing the conventional FFT spectrometers by new spectrometers based upon the FPT [*1*, *2*].

Recently, ICR mass spectroscopy has been used to achieve the unprecedented 1 per 8 000 000 resolution $m/\Delta m_{50\%}$ for weighing biomolecular ions in strong magnetic fields, where $\Delta m_{50\%}$ is the full width at the half maximum. Nevertheless, this is not always sufficient when it comes to resolving isotopic isomers for heavy molecules. The mass resolution is directly proportional to the magnetic field strength, $m/\Delta m_{50\%} \sim B$. In the past several years, there has been an enhanced tendency towards tying the advances in FFT-ICR to increasing values of B. The high cost of strong magnets severely limits the number of institutions which can afford this important research. Currently only some five laboratories in the world could potentially have arrived at the quoted result. If the same mass resolution as above could be obtained with only $B/2$, hundreds of laboratories worldwide would also

(Continued on the next page.)

participate to the significant progress in ICR. This, coupled with the consensus that there could never be 'enough' resolution in a mass or frequency spectrum, prompted us recently [*1*, *2*] to devise an alternative strategy by using modern high-resolution signal processing, i.e., the theory and the related mathematical *software,* rather than exclusively *hardware,* to substantially increase the overall performance of ICR.

To achieve this goal, we suggest using FPT as the rational polynomial function which has a richer mathematical structure than FFT. This new method for ICR measurements should play a complementary role to FFT and the accompanying experimental technique could be called FPT-ICR. The FPT can extract hundreds of thousands of peak parameters (positions, widths, heights) nearly as fast as the FFT produces only an overall shape of a spectrum. Moreover, FPT requires shorter acquisition time (or exposure of a sample to magnets) than FFT. As opposed to a merely magnitude mode of FFT, the phase correction in *FPT yields an absorption spectrum with a doubled resolution* $m/\Delta m_{50\%}$ *relative to FFT for half stronger and more than twice cheaper magnets.* These unique capabilities of FPT hold great promise to process signals that carry more information than is generally possible to extract by FFT. The algorithm of FPT has already been ported to various platforms and the possibilities of incorporating FPT into commercial ICR and NMR spectrometers are under study. This could lead to a significantly enhanced performance and/or lower costs of many research projects employing mass-frequency-energy spectrometry and of a variety of Fourier-based interdisciplinary fields. Also a future use of FPT in technologies, e.g., low bit rate speech coding, as in cellular telephones, is envisaged.

More than two decades ago, after the success of Nuclear Magnetic Resonance (NMR) based upon the Fast Fourier Transform (FFT), chemists introduced FFT-ICR (Ion Cyclotron Resonance) mass spectroscopy to study molecular structure, reactivity and bonding. Nowadays, physicists promote ICR to one of the most fundamental levels by performing high precision measurements of the masses m_{p^-} and m_{p^+} of the antiproton and the proton. Any statistically significant difference detected between m_{p^-} and m_{p^+} would be of paramount importance, altering radically the present views on nature's symmetries and demanding a novel theory on matter-antimatter liaison.

Measured signals are 'noisy' and are virtually impossible to analyse directly in the time domain. For this reason, one customarily resorts to a more easily visualized frequency spectrum. But here again noise often precludes adequate interpretations of spectra. In ICR, the main goal is to determine precisely the peak parameters from measurements of time signals in the presence of noise. The first idea which comes to mind is to perform the simple 'signal averaging' technique. Carrying out 'the same' measurement a sufficient number of times and taking the arithmetic average of the obtained results would tend to reduce the effect of noise. Signal averaging would not be adequate for ICR. Given the quest for a high accuracy mass determination, the present-day experimental conditions cannot provide circumstances that could be considered as being sufficiently 'the same' for repeated trials of the given measurement. Hence the request that the principal parameters of each genuine spectral peak should be determined from *a single-scan* spectrum, bypassing completely signal averaging. Having performed the FFT on noisy time signals, one often obtains severely distorted frequency or energy spectra. This is due to the linearity of the FFT, which amplifies additive noise. By contrast, the Fast Padé Transform (FPT) is capable of significantly reducing random noise from any frequency spectra by using its nonlinearity to effectively *manipulate with noise* [*1*, *2*]. This is possible because FPT is a generic *parameter spectral estimator* which provides the position, width and magnitude of each line from the first principles of the Cauchy calculus of residue without resorting to any fitting. By com-

(Continued on the next page.)

parison, the FFT is a *non-parametric spectral estimator* which yields merely an overall lineshape, and the peak parameters might be approximately extracted only by a post-processing fit to certain prescribed forms (Lorentzians, Gaussians, etc.). In FPT, we first obtain the quoted peak parameters with the highest precision and then construct a spectrum. The only free input in FPT is the signal length. The FFT must exhaust the full signal length in order to achieve the necessary resolution. We do not have this constraint since the nonlinearity of FPT helps us to converge much before the full signal length is utilized. This is the main advantage of FPT over FFT, since longer signals inevitably involve a considerable amount of noise. Envelopes of time signals usually decay exponentially with an increased time epoch and this leads to serious noise corruption of long signals. Such a problem could easily reach a level which might hamper the successful completion of the required spectral analysis, as is actually the case in ICR mass spectroscopy.

To reduce noise, we take advantage of the computed table of positions, widths and magnitudes of each peak in a spectrum *before* we construct it in a final form. Random noise is a stochastic phenomenon which cannot be adequately described by any mathematical model with well-controlled outputs. Therefore, noise peaks in a spectrum will be exceedingly sensitive to any alteration in a given method. In FPT, we monitor the sensitivity of the peak parameters relative to the signal length. Generally, we observe that the genuine, physical peaks are stable to within a prescribed threshold accuracy. Unstable peaks are identified as noise and removed from the spectral representation of FPT. Both mathematical and physical justification for this strategy within FPT can be found. According to the Fröbenius-Froissart theorem for a rational polynomial function, as the one in FPT, changing the signal length, while passing from the diagonal to para-diagonal elements in a two-dimensional Padé table, leaves the true poles virtually unaltered, whereas the spurious, extraneous resonances exhibit great instability.

Physically, there is an analogy between noise and a background contribution in resonance scattering phenomena in atomic and molecular physics. The FPT converges fast and *first* for those poles having the imaginary part of frequencies close to the unit circle. These poles are near the real axis and represent a localized wave packet comprised only of a limited number of continuum states that are excellently handled by a converged local order of the compact FPT. Poles situated far from the real frequency axis ought to collect a great deal of considerably spread continuum 'noisy' states which are not well described by the compact FPT. In such poles, small variations of the signal length would introduce great instability. This is a clear *signature* of noise which can afterwards be rejected from the final spectrum. To make sure that none of the genuine signal poles is lost while 'denoising' the spectrum, however weak they might be, we perform various *cross validations* of FPT, e.g., using its forward-backward 'walks' through the Padé table or by supplementing time signals with an additional $5\%-10\%$ random white noise. Stable structures which fully agree in all the peak parameters with the corresponding findings from the previous runs of the FPT algorithm are classified with fidelity as the true peaks and they are the only ones which survive our signal 'denoising' procedure. The power of this versatile technique has been proven in many examples where FPT was effectively 'coupled' to experiments in our pursuit to improve resolution. In these illustrations, we used measured ICR and NMR time signals to compute magnitude or absorption spectra and always obtained greatly enhanced resolution with FPT relative to FFT, simultaneously achieving a considerable improvement of the signal-to-noise ratio. Supporting evidence will be presented at this course following the suggested literature. Finally, closing this detailed description of the course, we shall illustrate one of the lectures as an application of the presented methods. The subject is:

(Continued on the next page.)

Interactions of Light Ions with Tissue

Interactions of light ions with tissue are much more complex than those involving electron or photon beams while penetrating the human body during cancer therapy. This is because many more transition channels are open to ions than to electrons or photons. Knowledge of electron production cross sections is crucial for modelling of transport of ions in tissue, relative biological effectiveness (RBE), ionizing break-up of DNA, etc. For a deeper understanding of the tissue response to ionizing radiations, accurate data on spatial distributions of energy depositions are required. M. Berger and M. Inokuti rightly pointed out in their recent ICRU report that *"unless one knows correctly atomic/nuclear cross sections and stopping powers, one has no hope of studying the energy deposition in any greater detail".* These observables are necessary to predict e.g. creation of inner shell vacancies in multielectron atoms (C, N, P or O) of the DNA skeleton that can lead, via Auger electrons and Coulomb explosion, to double strand breaks, aberration, inactivation and mutation of cells. To investigate the basic mechanisms in these key phenomena, we implemented the most advanced distorted wave multiple-centre atomic/nuclear scattering theories, by going beyond the usual Born-Bethe model, which has severely limited the past conclusions in radiotherapy. Atomic collisions dominate in the keV/u and low MeV/u energy region where excitation, ionization and electron transfer must properly be described for reliable predictions of ion energy losses.

Atomic interactions of light ions with tissue at the keV/u and sub-keV/u energies are essential for adequate estimates of RBE, which together with the linear energy transfer (LET), determines which ions should be selected for the most beneficial cancer therapy with the maximal eradication of clonogenic cells and minimal damage of the healthy tissue. To reach the deep-seated tumours at the depth of the order of ~ 25 cm in tissue, very high energies of the ion beam are necessary, e.g. 360 MeV/u for $^{12}C^{6+}$. At these energies, nuclear reactions must be considered, as the neutron losses dominate over atomic processes. Our unified distorted wave theory for atomic and nuclear collisions can quantitatively explain e.g. an important recent experimental finding that, just like the K-shell atomic ionization, inactivation cross sections attain their maxima for the matching resonance condition between the velocities of the incident ion and the K-shell electron. This could trigger possible radiation damage of DNA in the tumour, a process which must be enhanced to stop the production and proliferation of clonogenic cells. The present theory of ion-tissue interactions can yield the needed cross sections for one or two neutron losses from ionic projectiles, an important phenomenon which widens the Bragg peak beyond the tumour area.

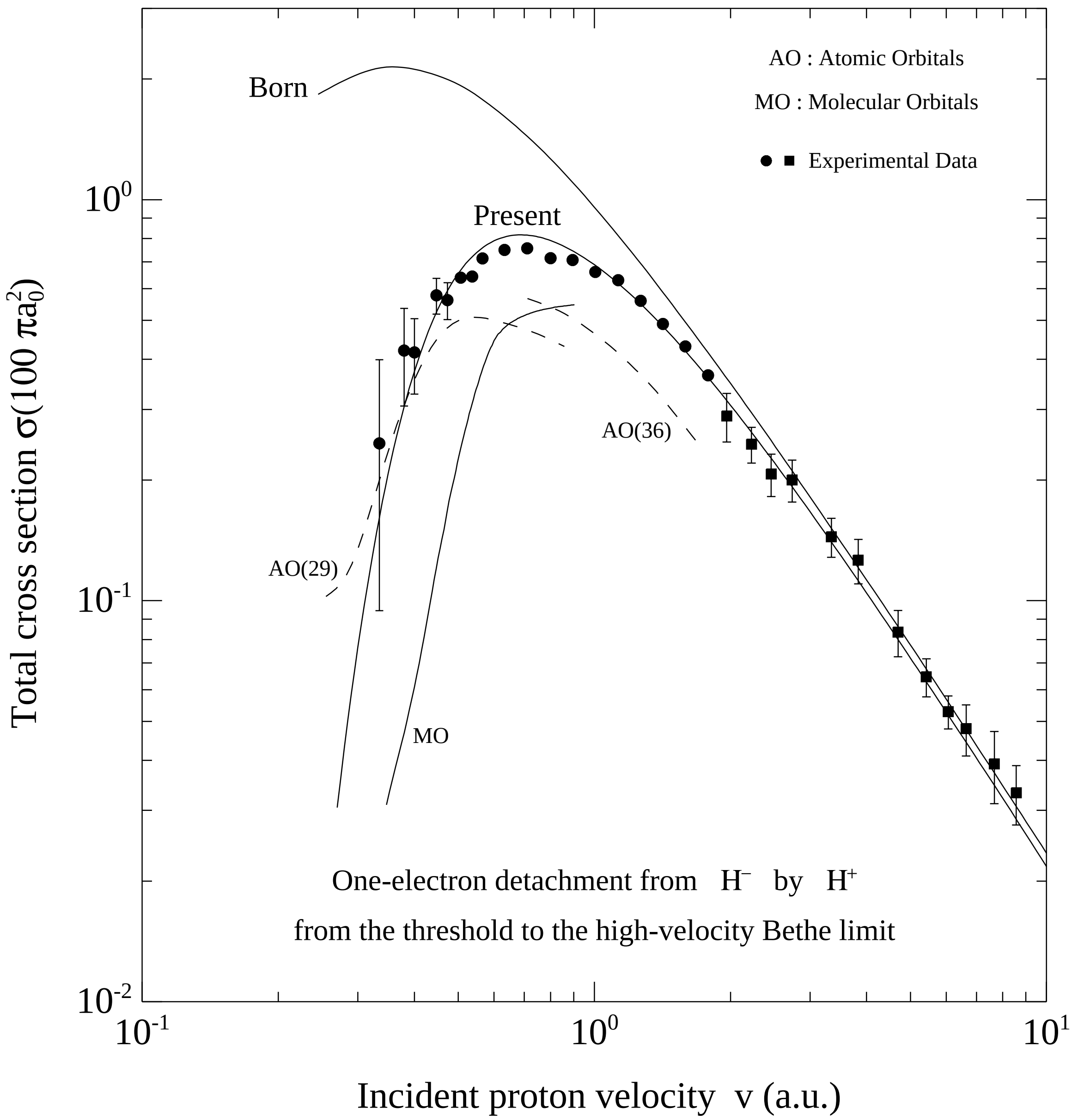
The dose delivery by ions that are β^+-emitters can be accurately monitored via PET imaging of the Bragg beak within the tumour area. Here, as well as in other diagnostic imagings (MRI), that are indispensible to precisely determine the target volume, we use our high-resolution, noise-reduced signal and image processing method, Fast Padé Transform (FPT), to enhance performance of the overall diagnostic-therapeutic procedures in dealing with the cancer problem.

There has been no comprehensive 3D code available thus far, which simultaneously employs the best existing atomic/nuclear physics theories for the most accurate modelling of light ion transport in tissue, with the subsequent production of the secondary δ electrons, and an interactive follow-up via improved PET imaging. Our physically and biologically optimized algorithm, in the versatile setting of the FPT, from treatment planning and ion transport to imaging, fills in this gap and provides a powerful tool which could become a part of a future clinical protocol for cancer therapy by light ions. In assessing the validity of employed theoretical models, we choose a number of critical tests, such as the example

(Continued on the next page.)

shown in the displayed Figure. Here, experimental data (circles and squares) for single-electron detachment in one of the most correlation-sensitive reactions, $H^+ + H^-(1s^2) \longrightarrow H^+ + H + e$, are used to illustrate the superiority of the present theory (middle full line) relative to the first Born approximation (top full line), the molecular orbital expansion (bottom full line), and the atomic orbital expansion with 29 (left dashed line) and 36 (right dashed line) basis set functions. Similar situations/conclusions are also encountered for other targets, e.g. H_2O, C, N, P, O, and DNA which is modelled by the Bragg sum rule via addition of the associated atomic cross sections.

Dževad Belkić



(Continued on the next page.)

Book information from the publisher

DŽEVAD BELKIĆ, *The Principles and Methods of Quantum Scattering Theory.* Institute of Physics Publishing Ltd. (Bristol, England), to appear in March 2001, 272 pp, illustrated, hardback, 0750304960. Price £45.00, US$75.00.

Subject area

Atomic, Molecular and Plasma Physics, Applied Mathematics, Medical Science, Mathematical Physics, Computational Physics.

Synopsis

This book, developed from the author's central journal review paper, deals in a comprehensive manner with the theory of quantum scattering. In addition, it presents the fundamental physics of particle collisions built from first principles and culminates in a unified treatment of scattering and spectroscopy within the generic concept of the autocorrelation function. Among all the basic and practical techniques, the Padé approximant is established in this book as the most powerful and versatile method, which requires the least computational effort to provide the optimally accurate results.

Founded on general principles, the theory presented in this book covers much ground and finds application in many areas of physics ranging from atomic and molecular physics to astrophysics, plasma physics, medical imaging, and also nuclear fusion.

This book comes complete with a set of integrated, fast and optimized algorithms. These robust codes illustrate the presented standard as well as new theoretical methods and also fully equip the reader with many of the modern mathematical tools needed to pioneer new research in this exciting field.

Readership

Researchers in atomic and molecular physics, fundamental scattering theory, spectroscopy, applied mathematics, signal and image processing, optimization, and inverse problems.

Content

Introduction. Physical aspects of collision problems. Universality of the collision problem. The key properties of quantum collisions. The Kato conditions. Time evolution of quantum systems. The Schrödinger picture. The Heisenberg picture. The Dirac picture. The Dyson perturbation expansion. Time-dependent theory of scattering. Time-independent theory of scattering. Strong and weak convergence. Convergence of vectors and matrices. The asymptotic convergence of states. The S-matrix and the T-matrix. The Levinson theorem. Interaction of ions with matter. The Boltzmann equation. Rotated coordinate method. Stabilization method. R-matrix method. Variational principles. The Fredholm integral equations. The Fourier transform. Filter diagonalization. Decimated signal diagonalization. Linear predictor, MUSIC, ESPRIT. Maximum entropy, COMET. The PADE approximant, ARMA. Unification of scattering and spectroscopy. Computerized analytical continuation. Optimization in inverse problems. Signal and image processing. Discussion and conclusion. Appendices.

Highlights

Fundamental and practical quantum scattering theory is presented from the first principles of physics relying upon a rigorous mathematical formalism. This is done by intertwining the physical content of the scattering problem with the basic strong topology of vector spaces and spectral operator analysis. Such a foundation permits an introduction of the leading methods of scattering within the same framework of Green's function, the Padé

(Continued on the next page.)

approximant, auto- and cross-correlation functions. This versatile formalism is shown to be common to spectroscopy as well as to signal and image processing. This is due to the established equivalence between auto-correlation functions and time signals which correspond to Lorentzian spectra. The signals used in this book are of a generic nature and they could stem from experiment and/or theory. The measured signal points can directly fill-in the evolution matrix, whose generalized diagonalization extracts the whole spectral information about the studied system. A number of modern parametric spectral estimators are thoroughly analysed in this book. These include filter diagonalization, linear predictor, maximum likelihood, maximum entropy, decimated signal diagonalization, continued fractions, the Padé approximant, etc. The conclusion is that the Padé approximant is the method of choice due to its optimal accuracy and efficiency for scattering, spectroscopy, inverse reconstruction problems, etc.