THE Crafoord PRIZE

Crafoord *Days* 2012

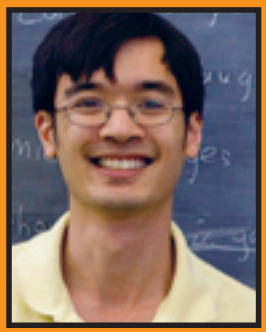
14–15 MAY, LUND, SWEDEN

Abstracts

Programme

The Crafoord Prize in Mathematics 2012
The Crafoord Prize in Astronomy 2012


JEAN BOURGAIN


TERENCE TAO


REINHARD GENZEL


ANDREA GHEZ

Anna-Greta and Holger Crafoord Fund

THE FUND WAS ESTABLISHED in 1980 by a donation to the Royal Swedish Academy of Sciences from Anna-Greta and Holger Crafoord. The Crafoord Prize was awarded for the first time in 1982. The purpose of the Fund is to promote basic scientific research worldwide in the following disciplines:

- Mathematics
- Astronomy
- Geosciences
- Biosciences (with particular emphasis on Ecology)
- Polyarthritis

Support to research takes the form of an international prize awarded annually to outstanding scientists and of research grants to individuals or institutions in Sweden. Both awards and grants are made according to the following order:

year 1: Mathematics and Astronomy
year 2: Geosciences
year 3: Biosciences (with particular emphasis on Ecology)
year 4: Mathematics and Astronomy
year 5: Geosciences
year 6: Biosciences (with particular emphasis on Ecology)
and so on

The Prize in Polyarthritis is awarded only when a special committee has shown that scientific progress in this field has been such that an award is justified.

Part of the Fund is reserved for appropriate research projects at the Academy's institutes. The Crafoord Prize presently amounts to SEK 4 million, for the year 2012 the prizes in Mathematics and Astronomy are awarded with SEK 4 million each. In addition to the prize, financial support is granted to other researchers in the same field in which the prize is awarded for that year.

The Crafoord Prize is awarded by the Royal Swedish Academy of Sciences.

Content

The masters of mathematics

This year's Crafoord Prize Laureates have solved an impressive number of important problems in mathematics. Their deep mathematical erudition and exceptional problem-solving ability have enabled them to discover many new and fruitful connections and to make fundamental contributions to current research in several branches of mathematics.

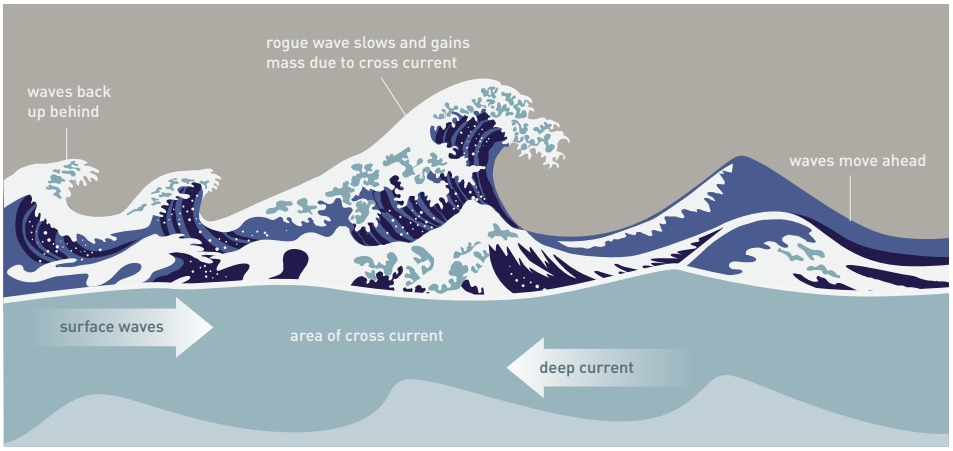


Illustration: Johan Jarnestad/Swedish Graphics. ©The Royal Swedish Academy of Sciences

Both Crafoord Laureates contributed to the study of some of the most difficult, non-linear differential equations which describe such processes as turbulent currents, tsunami waves and chaos.

On their own and jointly with others, **Jean Bourgain** and **Terence Tao** have made important contributions to many fields of mathematics – from number theory to the theory of non-linear waves. The majority of their most fundamental results are in the field of mathematical analysis. They have developed and used the toolbox of analysis in groundbreaking and surprising ways. Their ability to change perspective and view problems from new angles has led to many remarkable insights, attracting a great deal of attention among researchers worldwide.

The dark heart of the Milky Way

This year's Crafoord Prize Laureates have found the most reliable evidence to date that supermassive black holes really exist. For decades **Reinhard Genzel** and **Andrea Ghez**, with their research teams, have tracked stars around the center of the Milky Way galaxy. Separately, they both arrived at the same conclusion: in our home galaxy resides a giant black hole called Sagittarius A*.

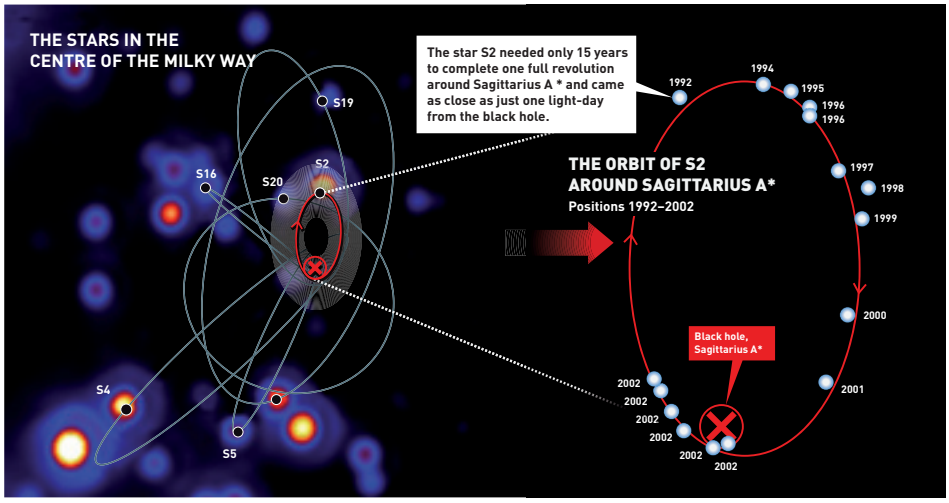


Illustration: Johan Jarnestad/Swedish Graphics. ©The Royal Swedish Academy of Sciences

Sagittarius A* – the supermassive black hole of our own galaxy, the Milky Way, forces the stars to move around it. For decades Reinhard Genzel, Andrea Ghez and their research colleagues tracked the motions of the stars in an attempt to achieve an optimal model of their orbits. One of the stars, S2, completed a full orbit around the Galactic Center in 15 years.

Black holes are impossible to observe directly – everything in their vicinity vanishes into them, virtually nothing is let out. The only way of exploring black holes is to investigate the effects their gravitation has on the surroundings. From the motions of stars around the center of the Milky Way, Reinhard Genzel and Andrea Ghez, and their colleagues, estimated the mass of Sagittarius A* at nearly four million times solar masses. Sagittarius A* is our closest supermassive black hole. It allows astronomers to better investigate gravity and explore the limitations of the theory of relativity.

Photo: ESO/S. Gillessen et al.

An image in infrared of the stars orbiting the Milky Way's central black hole, Sagittarius A*. The distance to the black hole is about 26 000 light years – the light we see today was sent away when the Earth still had full ice age.

The Crafoord Prize Laureates in Mathematics 2012

Photo: www.diplomatie.belgium.be

JEAN BOURGAIN,
INSTITUTE FOR ADVANCED STUDY,
PRINCETON, NJ, USA

Belgian citizen. Born 1954 in Ostende, Belgium. Ph.D. 1977 at Vrije Universiteit Brussels, Belgium. Professor at Institute for Advanced Study, Princeton, NJ, USA.

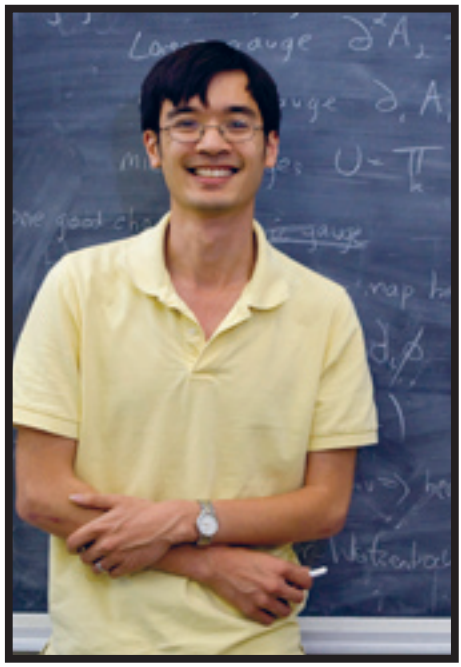


Photo: Reed Hutchinson, UCLA

TERENCE TAO,
UNIVERSITY OF CALIFORNIA, LOS ANGELES,
CA, USA

Australian and American citizen. Born 1975 in Adelaide, Australia. Ph.D. 1996 at Princeton University, NJ, USA. Professor at University of California, Los Angeles, CA, USA.

The Crafoord Prize Laureates in Astronomy 2012

Photo: MPE

REINHARD GENZEL,
MAX PLANCK INSTITUT FÜR EXTRATERRESTRISCHE PHYSIK, GARCHING, GERMANY

German citizen. Born 1952 in Bad Homburg vor der Höhe, Germany. Ph.D. 1978 at Universität Bonn, Germany. Professor at University of California, Berkeley, CA, USA and Scientific Director of Max Planck Institut für extraterrestrische Physik, Garching, Germany.

Photo: Matt Boatright-Simon

ANDREA GHEZ,
UNIVERSITY OF CALIFORNIA, LOS ANGELES, CA, USA

American citizen. Born 1965 in New York City, NY, USA. Ph.D. 1992 at the California Institute of Technology, CA, USA. Professor at the University of California, Los Angeles, CA, USA.

Diophantine applications of group expansion

JEAN BOURGAIN, CRAFOORD LAUREATE 2012
INSTITUTE FOR ADVANCED STUDY, PRINCETON, NJ, USA

Recent developments around group expansion led to a vast generalization of Selberg's eigenvalue theorem for congruence subgroups of SL_2(Z). These results may then be combined with Lax-Phillips theory or thermodynamical methods in order to produce exact counting results in the orbits of 'thin groups' and those may be further applied to number theoretic questions. In the talk, two such applications involving group actions will be discussed. The first are the diophantine properties of the curvatures in integral Apollonian circle packings and the second is Zaremba's conjecture on continued fraction expansions.

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Universality and random matrix theory

TERENCE TAO, CRAFOORD LAUREATE 2012
UNIVERSITY OF CALIFORNIA, LOS ANGELES, CA, USA

A remarkable phenomenon in random matrix theory is that of universality: that large classes of random matrix models end up having the same universal spectral statistics in the asymptotic limit when the size of the matrix goes to infinity. (In fact, the phenomenon extends beyond random matrix theory; the same asymptotic distributions are also conjecturally present in an astonishing array of other systems, ranging from bus waiting times in Mexico to the spacing between zeroes of the Riemann zeta function.) A typical example of universality is the Wigner semicircle law for the bulk eigenvalue distribution of a random matrix, which holds for a very wide variety of random matrix models, and is analogous to the central limit theorem in classical probability theory. In recent years there has been much progress in obtaining a rigorous understanding of the universality phenomenon, particularly for Wigner-type models (such as random sign matrices or the Gaussian Unitary Ensemble) in which many of the entries of the matrix fluctuate independently. In this talk we survey some of this recent progress, and the new methods used to establish these results.

References

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Tao, T., Vu, V. (2011) Random matrices: universality of local eigenvalue statistics, *Acta Mathematica*, 206, 1: 127–204.

Arithmetic progressions and near equality in affine-invariant inequalities

MICHAEL CHRIST, UNIVERSITY OF CALIFORNIA, BERKELEY, CA, USA

Arithmetic progressions are among the most basic mathematical structures. Fundamental works of Bourgain and of Tao have dramatically reshaped our view of their role, and more generally the role of additive combinatorial techniques, in analysis. This talk will outline recent investigations of extremizers and/or near-extremizers for certain affine-invariant analytic inequalities. Among these are Young's convolution inequality, the Riesz-Sobolev rearrangement inequality, and an inequality for the Radon transform. A characterization of finite sets which are nearly equal to arithmetic progressions, due to Freiman, is a key ingredient.

References

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A personal perspective on some of the work of Bourgain and Tao

BEN GREEN, UNIVERSITY OF CAMBRIDGE, UK

My aim in this talk is to discuss some of the results of Jean Bourgain and Terry Tao that have influenced (and interested) me the most. I will start in the obvious place, namely a discussion of their only joint paper: a sum-product theorem in $\mathbb{F}_p$, joint with Nets Katz. In this paper they establish that if $A \subseteq \mathbb{F}_p$ and if $p^{\delta} < |A| < p^{1-\delta}$ then either the set of products $A \cdot A := \{a_1 a_2 : a_1, a_2 \in A\}$ or the set of sums $A + A := \{a_1 + a_2 : a_1, a_2 \in A\}$ is significantly bigger than A. I will sketch the ingenious proof of this result, which took inspiration from an idea of Edgar and Miller on Erdős's ring problem. I may then hint at some applications, including spectacular advances on the problem of bounding exponential sums over multiplicative subgroups of $\mathbb{Z}/p\mathbb{Z}$.

Next I will turn to the Kakeya problem, on which both laureates have done important work. A Kakeya set, or Besicovitch set, is a subset of $\mathbb{R}^n$ containing a unit line segment in every direction. It is known that such sets can have zero measure; however, it is suspected that they must have Hausdorff dimension n. I will mention Bourgain's work giving the first bound of the form $d > (\frac{1}{2} + c)n$ for $c > 0$.

This work provided the first connection of the problem to additive combinatorics, a direction that was subsequently pursued by Katz and Tao. I will discuss a little of this work, including the intriguing "arithmetic" Kakeya problem. I may also mention (briefly) connections between the Kakeya problem and certain conjectures of Montgomery in number theory, if only because this was the first work of Bourgain that I personally read, and I may make some remarks on the restriction problem.

In connection with his work on Kakeya in the late 1990s, Bourgain established the bound $|A| \ll N(\log N)^{-1/2+o(1)}$ for the maximal size of a set $A \subseteq \{1,\dots,N\}$ containing no 3-term arithmetic progression. The techniques developed therein have had substantial influence on additive combinatorics, and I will talk a little about them.

Finally, I will discuss miscellaneous results of the two authors that I like. I may mention the work of Bourgain on sum-free sets, or some of the foundational work of Tao on approximate groups.

Analysis of Boolean functions

GIL KALAI, HEBREW UNIVERSITY, ISRAEL

A few results and two general conjectures regarding analysis of Boolean functions, influence, and threshold phenomena will be presented.

Boolean functions are functions of n Boolean variables with values in {0,1}. They are important in combinatorics, theoretical computer science, probability theory, and game theory.

Influence. Causality is a topic of great interest in statistics, physics, philosophy, law, economics, and many other places. If causality is not complicated enough, we can ask what is the influence one event has on another one. Ben-Or and Linial 1985 paper studied influence in the context of *collective coin flipping* – a problem in theoretical computer science.

Fourier. Over the last two decades, Fourier analysis of Boolean functions and related objects played a growing role in discrete mathematics, and theoretical computer science.

Threshold phenomena. Threshold phenomena refer to sharp transition in the probability of certain events depending on a parameter p near a critical value. A classic example that goes back to Erdős and Rényi, is the behavior of certain monotone properties of random graphs.

Influence of variables on Boolean functions is connected to their Fourier analysis and threshold behavior, as well as to **discrete isoperimetry** and **noise sensitivity**.

The first Conjecture to be described (with Friedgut) is called the Entropy-Influence Conjecture. (It was featured on Tao's blog.) It gives a far reaching extention to the KKL theorem, and theorems by Friedgut, Bourgain, and me.

The second Conjecture (with Kahn) proposes a far-reaching generalization to results by Friedgut, Bourgain and Hatami.

References

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A case study for critical non-linear dispersive equations: the energy critical wave equation

CARLOS KENIG, UNIVERSITY OF CHICAGO, IL, USA

In this lecture we will illustrate some recent developments in the theory of nonlinear dispersive equations and forecast some possible future developments, by means of one example, namely the energy critical wave equation in three space dimensions. The issues studied are global existence, finite time blow-up, scattering and soliton resolution.

References

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Massive black holes: from discovery to cosmic evolution

REINHARD GENZEL, CRAFOORD LAUREATE
MAX PLANCK INSTITUT FÜR EXTRATERRESTRISCHE PHYSIK, GARCHING, GERMANY

Accretion of matter onto massive black holes was proposed five decades ago as an explanation for the luminosities of the mysterious distant quasars. Over time and owing to the remarkable progress in astrophysical measurements across the electromagnetic spectrum, this hypothesis has evolved from speculation to virtual certainty. Massive black holes are now thought to be ubiquitous in most galaxy nuclei. This includes our own Milky Way, which currently provides the strongest empirical evidence for the black hole paradigm. It has become clear that most of these massive black holes were formed during the epoch of galaxy formation, 10–12 Gyrs ago. It is also probable that the interaction between the energy production of the growing black holes with their environment had a profound impact on the evolution of the host galaxies. The talk will discuss this remarkable and highly unexpected story of scientific exploration, summarize the key observational and theoretical findings, and end with an outlook of possible future developments.

The Galactic Center: unveiling the heart of our galaxy

ANDREA GHEZ, CRAFOORD LAUREATE
UNIVERSITY OF CALIFORNIA, LOS ANGELES, CA, USA

The proximity of the center of our Galaxy has presented us with a unique opportunity to study a galactic nucleus with orders of magnitude higher spatial resolution than can be brought to bear on any other galaxy. This advantage, along with the recent advances in high angular resolution imaging technologies, has allowed the first observations of individual stars at the very heart of a galaxy. After more than a decade, such observations have transformed the case for a supermassive black hole at the Galactic Center from a possibility to a certainty, thanks to measurements of individual stellar orbits. The rapidity with which these stars move on small-scale orbits, indicates that 4 million times the mass of the sun resides within a region comparable to the size of our solar system. This provides the best evidence yet that supermassive black holes, which confront and challenge our knowledge of fundamental physics, do exist in the Universe. Subsequent high-resolution imaging studies of the Galactic Center have shown that the stellar population near our Galaxy's supermassive black hole is quite different from the predictions of theoretical models for the interaction between central black holes and their environs (an essential input into models for the growth of nuclear black holes). In particular, the observations have revealed an abundance of young stars in a region that is inhospitable to star formation and, conversely, a dearth of old stars where a stellar cusp is expected. Further improvements in measurement precision should enable tests of Einstein's theory of General Relativity in the extreme environment near a supermassive black hole.

Infrared radiation from the vicinity of the newly discovered massive black hole: forty-five years of observations

ERIC BECKLIN, UNIVERSITY OF CALIFORNIA, LOS ANGELES, CA, USA

The first measurements of the infrared radiation from the center of the Milky Way Galaxy occurred in 1966 at Mount Wilson Observatory. The observations at 1.65, 2.2 and 3.4 microns showed that the radiation was primarily from stars with about 25 magnitudes of visual extinction due to interstellar dust. When corrected for extinction, the brightness and distribution of stars was similar to nearly spiral galaxy M 31. (Becklin and Neugebauer 1968 ApJ 151 p145). The peak surface brightness was within a few arcsecs of the non thermal radio source Sgr A* discovered by Balick and Brown in 1974 (ApJ 194 p265). Observations in the thermal Infrared at 10, 20, 50 and 100 microns showed that there was also heated dust in the region. Kuiper Airborne Observatory measurements found that the cooler dust was in a 1 parsec ring centered around the peak distribution of stars and the radio source Sgr A*, (Becklin, Gatley and Werner 1982 ApJ 258, p 135). At about the same time, infrared spectral line measurements of the ionized gas and from stars indicated there was more mass in the central region than expected from the stars. Studies of the Galactic Center region at wavelengths between 1.65 and 3.5 microns changed dramatically in the late 1980's with the development of infrared arrays with over 1000 pixels (i.e. Forrest, Pipher and Stein 1986 ApJ Letters, 301, pL49). A revolution was taking place, especially when combined with the development of large telescopes and adaptive optics. In the thermal infrared, arrays were also creating new discoveries and the latest images of the dust emission will be presented and discussed.

References

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Balick, B., Brown, R. L. (1974) Intense sub-arcsecond structure in the Galactic Center, *Astrophysical Journal*, 194:265-270.

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The instruments behind the discovery of the Galactic Center black hole and the origin of the orbiting stars

FRANK EISENHAUER, MAX PLANCK INSTITUT FÜR EXTRATERRESTRISCHE PHYSIK, GARCHING, GERMANY

Astronomical discoveries go hand in hand with the development of novel telescopes and instruments. This lecture introduces the fascinating astronomical instruments behind the observations of the Galactic Center black hole: active telescopes, adaptive optics, imaging spectroscopy, and interferometry. The super-sharp images from adaptive optics trace the stellar orbits, the precise position measurements from interferometry pin down the black hole, and the imaging spectroscopy tells the nature of the orbiting stars. These stars are surprisingly young, so young that the origin of these stars remains one of the biggest puzzles about the Galactic Center. Starting from the spectra of these stars, this lecture summarizes what we know about the swarm of the S-stars in the central light month and the surrounding disc of young, very massive stars. The lecture will end with an outlook on the next generation instruments to directly explore the physics close to the event horizon of the Galactic Center black hole.

Fueling star formation around Andromeda's supermassive black hole

JESSICA LU, UNIVERSITY OF HAWAII, HI, USA

The neighbouring Andromeda galaxy (M31) harbours both a supermassive black hole and a 200 Myr starburst cluster within the central parsec. The nucleus of M31 has little molecular gas; therefore the source of fuel for this recent star formation event has not yet been determined. One proposed solution is that an eccentric disk of old stars, observed to extend a few parsecs from the black hole, is both the source of the molecular gas and the means for transporting the gas inward. We test this hypothesis with Keck adaptive optics integral field spectroscopy of the entire eccentric disk and central parsec. We have mapped the 2D kinematics in this region in order to measure the dynamical structure of the eccentric disk and determine if the disk is precessing slowly enough to produce intersecting orbital paths. Gas ejected by stellar winds could then collide, shock, cool, and plunge into the central parsec to fuel future starbursts or black hole accretion. Similar conditions may arise in other galactic nuclei and lead to episodic nuclear starbursts, even in galaxies with little gas and low total star formation rates.

The fate of black holes in colliding galaxies

CLARIE E. MAX, UNIVERSITY OF CALIFORNIA, SANTA CRUZ , CA, USA

It is now known that most galaxies contain supermassive black holes in their cores, and that many are 100 to 1000 times more massive than the black hole in the center of our own Milky Way galaxy. Here we ask what happens to these supermassive black holes when gas-rich galaxies collide with each other. How often do both black holes accrete gas and emit large amounts of radiation? How often should we expect the two black holes to merge into one larger black hole? We are using adaptive optics, a new technology that removes blurring due to turbulence in the Earth's atmosphere, to address these questions.

References

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The Galactic Center in context: from sub-parsec to kiloparsec scales

RAINER SCHÖDEL, INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA – CSIC, GRANADA, SPAIN

The aim of this talk is to provide an overview of the environment, in which the Milky Way's central black hole is embedded. The central kiloparsecs of the Milky Way are dominated by *the galactic bulge/bar*, a region mainly composed of old, evolved stars, arranged in a bar with a major half-axis size of a few kiloparsecs. On scales of tens of parsecs, the smallest scales that we can resolve in all other but the most nearby galaxies, the main building blocks of our galaxy are *the nuclear stellar disk*, with a radius of roughly 200 parsec and *the nuclear star cluster*, with a radius on the order of 10 parsec. Together, they form the so-called *nuclear bulge*, which stands out from the kiloparsec-scale galactic bar by an apparent disc-like morphology, a very high density of stars, the presence of large amounts of clumpy molecular gas, and high star forming activity. So far, we only have a rough idea of the physical properties of this region, but still lack a detailed picture. This is because of the singular challenges that exist for observations of the Galactic Center, particularly the extreme interstellar extinction and the need for high angular resolution. Nuclear star clusters can be found at the dynamical centers of all but the most massive galaxies. They are probably the densest and most massive star clusters in the universe, but are still poorly understood. The Milky Way nuclear star cluster is a unique template for understanding nuclear clusters because it is the only one of its kind which we can resolve into individual stars. Its properties are similar to the extragalactic nuclear star clusters, but there are still important uncertainties concerning its shape and dynamics. Finally, at the very smallest scales in the Galactic Center, we encounter the so-called S-stars that orbit the central black hole. Intriguingly, these stars may be linked to the so-called hypervelocity stars that are observed in the galactic halo, at distances of tens of kiloparsecs.

Programme Crafoord Days

Monday 14 May

LUND

INTERNATIONAL PRIZE SYMPOSIUM IN MATHEMATICS **08:45–16:30**

From chaos to harmony

LECTURE HALL 1C, CENTRE FOR MATHEMATICAL
SCIENCES, LUND UNIVERSITY, SÖLVEGATAN 18, LUND

INTERNATIONAL PRIZE SYMPOSIUM IN ASTRONOMY **09:15–17:50**

Black holes and the centre of the galaxy

LUNDMARKSALEN, THE ASTRONOMY BUILDING,
LUND UNIVERSITY, SÖLVEGATAN 27, LUND

Tuesday 15 May

LUND

Crafoord Prize Lectures 2012 **09:00–12:30**

PALAESTRA HÖRSAL, LUND UNIVERSITY,
PARADISGATAN 4, LUND

No registration

Prize Award Ceremony **16:50–18:00**

In the presence of H.M. King Carl XVI Gustaf

MAIN ASSEMBLY HALL, UNIVERSITETSHUSET, LUND UNIVERSITY,
PARADISGATAN 2, LUND

For more information and registration: www.crafoordprize.se

INTERNATIONAL PRIZE SYMPOSIUM IN MATHEMATICS

From chaos to harmony

CHAIR: **CHRISTOPH THIELE**,
UNIVERSITY OF CALIFORNIA, LOS ANGELES, CA, USA

LUND
09:15–16:30

LECTURE HALL C
CENTRE FOR MATHEMATICAL SCIENCES
LUND UNIVERSITY, SÖLVEGATAN 18, LUND

Monday 14 May

THE SYMPOSIUM IS FREE OF CHARGE AND OPEN TO THE PUBLIC

08:45	Registration	
09:15	Opening address	*Staffan Normark*, Permanent Secretary of the Royal Swedish Academy of Sciences
09:30	*Diophantine applications of group expansion*	**CRAFOORD LAUREATE 2012** **JEAN BOURGAIN**, Institute for Advanced Study, Princeton, NJ, USA
10:20	*Analysis of Boolean functions*	*Gil Kalai*, Hebrew University, Israel
11:10	*A case study for critical non-linear dispersive equations: the energy critical wave equation*	*Carlos Kenig*, University of Chicago, IL, USA
12:00	Lunch	
13:30	*Universality and random matrix theory*	**CRAFOORD LAUREATE 2012** **TERENCE TAO**, University of California, Los Angeles, CA, USA
14:20	*A personal perspective on some of the work of Bourgain and Tao*	*Ben Green*, University of Cambridge, UK
15:10	Coffee break	
15:40	*Arithmetic progressions and near equality in affine-invariant inequalities*	*Michael Christ*, University of California, Berkeley, CA, USA
16:30	End of the symposium	

INTERNATIONAL PRIZE SYMPOSIUM IN ASTRONOMY

Black holes and the centre of the galaxy

LUND
09:45–17:50
LUNDMARKSALEN
THE ASTRONOMY BUILDING
LUND UNIVERSITY, SÖLVEGATAN 27, LUND

Monday 14 May

THE SYMPOSIUM IS FREE OF CHARGE AND OPEN TO THE PUBLIC

09:15	Registration	
09:45	Opening address	*Staffan Normark*, Permanent Secretary of the Royal Swedish Academy of Sciences
10:00	*Massive black holes: from discovery to cosmic evolution*	**CRAFOORD LAUREATE 2012 REINHARD GENZEL**, Max Planck Institut für extraterrestrische Physik, Germany
10:50	*The Galactic Center: unveiling the heart of our galaxy*	**CRAFOORD LAUREATE 2012 ANDREA GHEZ**, University of California, Los Angeles, CA, USA
11:40	*The Galactic Center in context: from sub-parsec to kiloparsec scales*	*Rainer Schödel*, Instituto de Astrofísica de Andalucía, Granada, Spain
12:30	Lunch	
14:00	*Infrared radiation from the vicinity of the newly discovered massive black hole: forty-five years of observations*	*Eric Becklin*, University of California, Los Angeles, CA, USA
14:50	*The fate of black holes in colliding galaxies*	*Claire E. Max*, University of Calfornia, Santa Cruz, CA, USA
15:40	Coffee break	
16:00	*The instruments behind the discovery of the Galactic Center black hole and the origin of the orbiting stars*	*Frank Eisenhauer*, Max Planck Institut für extraterrestrische Physik, Germany
16:50	*Fueling star formation around Andromeda's supermassive black hole*	*Jessica Lu*, University of Hawaii, HI, USA
17:50	End of the symposium	

Crafoord Prize Lectures 2012

LUND

09:00–12:30

THE OFFICIAL CRAFOORD PRIZE LECTURES AT PALAESTRA HÖRSAL, LUND UNIVERSITY, PARADISGATAN 4, LUND, SWEDEN

THE LECTURES ARE FREE OF CHARGE AND OPEN TO THE PUBLIC

No registration

Tuesday 15 May

09:00	Opening address	*Staffan Normark*, Permanent Secretary of the Royal Swedish Academy of Sciences *Nils Dencker*, the Prize Committee for Mathematics *Arne Ardeberg*, the Prize Committee for Astronomy
09:05	Introduction of the Laureates in Mathematics	*Anders Björner,* The Prize Committee for Mathematics
09:15	*Search for randomness*	**CRAFOORD LAUREATE IN MATHEMATICS JEAN BOURGAIN**, Institute for Advanced Study, Princeton, NJ, USA
09:55	*Structure and randomness in the prime numbers*	**CRAFOORD LAUREATE IN MATHEMATICS TERENCE TAO**, University of California, Los Angeles, CA, USA
10:35	Coffee break	
11:00	Introduction of the Laureates in Astronomy	*Arne Ardeberg,* The Prize Committee for Astronomy
11:10	*Massive black holes: from discovery to cosmic evolution*	**CRAFOORD LAUREATE IN ASTRONOMY REINHARD GENZEL**, Max Planck Institut für extraterrestrische Physik, Garching, Germany
11:50	*Journey to the Galactic Center*	**CRAFOORD LAUREATE IN ASTRONOMY ANDREA GHEZ**, University of California, Los Angeles, USA
12:30	End of the Prize Lectures	

Anna-Greta and Holger Crafoord

HOLGER AND ANNA-GRETA CRAFOORD

Holger Crafoord (1908–1982) was prominent in Swedish industry and commerce. He began his career with AB Åkerlund & Rausing and devoted a larger part of his working life to this company. In 1964, Holger Crafoord founded Gambro AB in Lund, Sweden, where the technique of manufacturing the artificial kidney was developed. This remarkable dialyser soon became world famous. Since then, a series of medical instruments has been introduced on the world market by Gambro.

In 1980, Holger Crafoord founded the Crafoord Foundation, which annually contributes greatly to the Anna-Greta and Holger Crafoord Fund.

Holger Crafoord became an honorary doctor of economics in 1972 and in 1976 an honorary doctor of medicine at the University of Lund.

Anna-Greta Crafoord (1914–1994) took, as Holger Crafoord's wife, part in the development of Gambro AB. Through generous donations and a strong commitment in the society around her, she contributed to the scientific and cultural life. In 1986 she founded the Anna-Greta Crafoord foundation for rheumatological research and in 1987 Anna- Greta Crafoord became an honorary doctor of medicine at the University of Lund.

Over the years, the Crafoords have furthered both science and culture in many ways and it is noteworthy that research in the natural sciences has received an important measure of support from the Anna-Greta and Holger Crafoord Fund.

THE ROYAL SWEDISH ACADEMY OF SCIENCES founded in 1739, is an independent, non-governmental organisation whose aim is to promote the sciences and strengthen their influence in society. Traditionally, the Academy takes a special responsibility for the natural sciences and mathematics, but in its work it strives to increase exchanges between different disciplines.

The activities of the Academy are aimed mainly at:

- *spreading knowledge of discoveries and problems in current research*
- *providing support for young researchers*
- *rewarding outstanding contributions in research*
- *stimulating interest in mathematics and the natural sciences in schools*
- *spreading scientific and popular-scientific information in various forms*
- *offering unique research environments*
- *maintaining contact with foreign academies, learned societies and other international scientific organizations*
- *representing the sciences in society*
- *carrying out independent analyses and evaluations, based on scientific grounds, of issues of importance for society*

The Academy has about 430 Swedish members and 175 foreign members. The Swedish members are active within Classes and Committees. They initiate investigations, responses to government proposals, conferences and seminars. Once a month the Academy holds a General Meeting and in connection with this a public lecture. (Visit http://kva.se for the programme.) The Academy´s own institutes offer unique research environments for botany, ecological economics, the history of science, astrophysics, mathematics and other subjects. Besides the prominent Crafoord Prize, the Academy awards annually a number of prizes, the best known of which are the Nobel Prizes in Physics and Chemistry and the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel. Other important prizes are the Söderberg Prize and the Göran Gustafsson Prizes. The latter are awarded to outstanding young researchers and are a unique combination of a personal prize and a research grant. The Academy also supports researchers who have been researching actively for five to ten years after taking their doctorate by providing a salary for five years through the support of external foundations. Through its various Committees the Academy also works for the development of a society based on scientific grounds. Great interest is paid to educational issues and a major school development program, NTA (Natural Sciences and Technology for All), is organized in collaboration with the Royal Swedish Academy of Engineering Sciences.

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