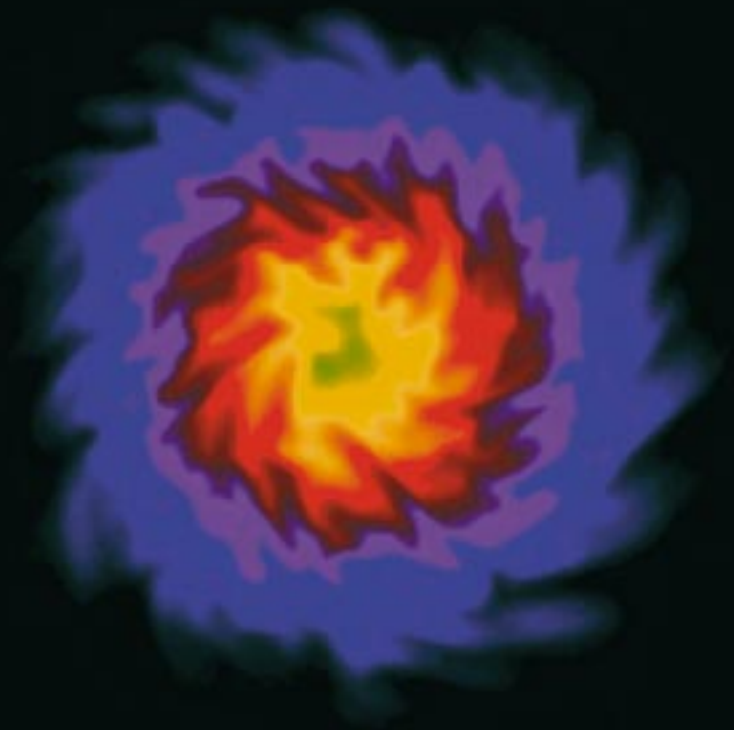
# Centre for Advanced Study

CAS OSLO

*Newsletter no. 1 • April 2005 • 13th year*


*The illustration shows a cross-section of the plasma trace of a dust particle meteor moving at high speed through the upper atmosphere.*



# Radar hunt for the secrets of meteor dust

The researcher Lars Dyrud is using radar in the hunt for dust particles that break the speed limit with a vengeance when they rush into the atmosphere at around 50 kilometres per second. These dust particles are actually minute meteors, and several thousand million of them arrive every single day. The purpose of the radar hunt is inter alia to learn more about the origin of the solar system. Pages 4–5

## The social utility of ADHD

It is obviously a disadvantage for an individual to have ADHD, but at the same time there are things to suggest that it is an advantage for society to have a certain proportion of hyperactive and impulsive members. "Perhaps it's the case that we need some people who can make mistakes we can learn from. How else should we find out which berries can be eaten?" asks the CAS researcher Jonathan Williams. Pages 2–3

## Words for numbers came with agriculture

There is a kind of logic in the fact that it will soon be only farmers who understand the complicated systems of public support for agriculture, as it was in fact the first agriculturists who "invented" words for numbers. «The earlier hunting and gathering cultures seldom had any need to count to much more than three,» says Professor Henning Andersen. Pages 6–7

# ADHD: It’s not only negative

There is no doubt that it is a burden for an individual to have ADHD. At the same time there is a great deal to suggest that it is an advantage for society as a whole to have a certain proportion of hyperactive and impulsive ADHD members. “Otherwise it becomes difficult to explain why the disorder is so widespread,” says Jonathan Williams.

The extent of the psychiatric disorder ADHD is strikingly similar in all cultures in which it has been mapped. Between three and five per cent of boys, and not quite so many girls, have ADHD. Children with ADHD are more at risk of becoming drug abusers if they are not diagnosed and treated, they have an increased risk of mild learning difficulties, and they are more likely to come into conflict with the law.

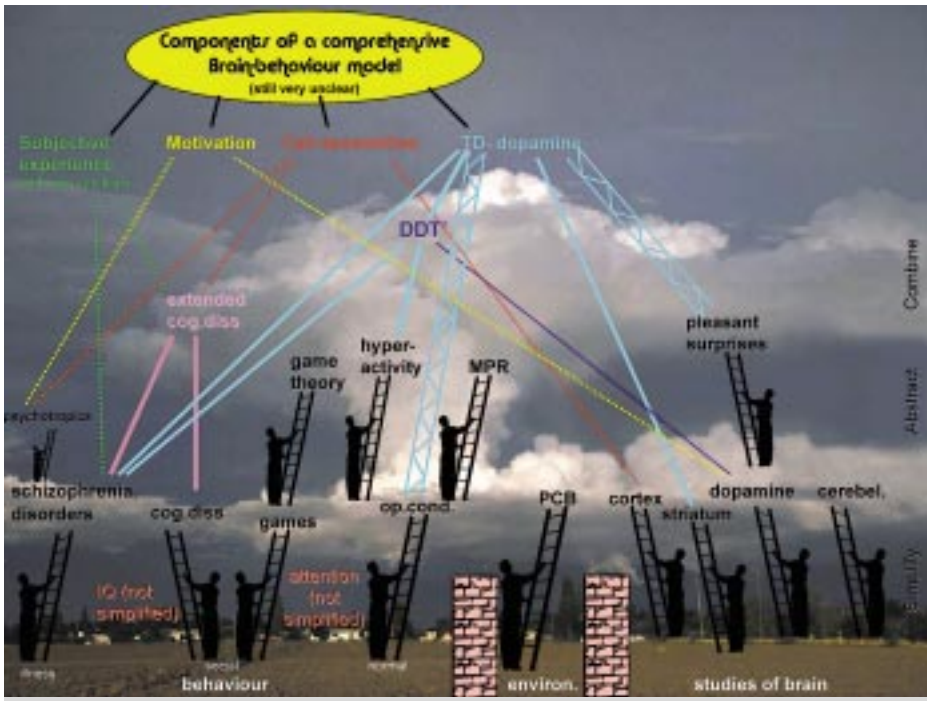
Researchers know at least six genes that increase the probability of developing the disorder. At the same time there is little to suggest that ADHD is a new disorder seen in a historical perspective. All this has made Jonathan Williams ask a surprising question.

“Why is a hereditary disorder so widespread in the population, if it is unfortunate for its individual members? Why has evolution failed to reduce the occurrence of ADHD? There are many factors affecting the individuals’ fitness, but it also seems likely that society as a whole benefits from the fact that a certain proportion of the population are hyperactive, impulsive or reckless. What is bad luck for the individual, can be good luck for society”, claims Williams.

Jonathan Williams is a psychiatrist at the University of London Institute of Psychiatry, and he has a background in both neurophysiology and computer technology as well as having worked as a general practitioner. He did some detailed computational modelling

## Bridge-building between research communities

■ The research group *Attention-deficit / Hyperactivity Disorder (ADHD) from Genes to Therapy* aims to build a bridge between basic research and the clinical understanding of ADHD. One of the aims is to develop an integrated understanding or model of ADHD. The group is headed by Professor Terje Sagvolden of the Institute of Basic Medical Sciences at the University of Oslo.




■ Jonathan Williams’ personal perspective of today’s research on the brain-behaviour relationships. Much important work is being done at the level of “basic science”, where researchers attempt to climb up the ladder of knowledge by collecting (simplifying) data in isolated areas. There is also a lot of good work going on at the level above, where researchers attempt to produce abstract theories that build on this basic research. The interest for Dr Williams lies in combining these abstract theories. Dotted lines are currently weak links; girders are the strongest links.

***Abbreviations:*** **DDT:** Professor Terje Sagvolden’s Dynamic Developmental Theory which describes the connections between such phenomena as impulsivity, hyperactivity, and dopamine action.

**TD:** Temporal Difference model of dopamine action.

Extended cog.diss: hypothesis linking cognitive dissonance to psychiatric disorders.

**MPR:** Mathematical Principles of Reinforcement.

**PCBs:** Environmental toxins.

## ADHD poses challe

**“As a disorder, ADHD represents a major challenge to psychiatric research. There are far too many researchers trying to find a key, fundamental cause of ADHD. But this kind of thinking goes off in quite the wrong direction,” says Jonathan Williams.**

Dr Williams is critical of much of the psychiatric research that has been carried out in the ADHD area, and he is in addition sceptical of calling ADHD a disorder. “By calling ADHD a disorder, we’ve implicitly adopted a medical model. This model says that if people have difficulties, then it’s a disorder that’s the cause. The single name encourages clinicians and many researchers to believe that there’s one single underlying cause behind it. But ADHD is poorly suited to this model”.

“ADHD has not been defined with reference to a parasite or something else in the natural world, but by a committee that has adopted a group of symptoms! This has misled a number of leading researchers into believing that they can find “Great Explanation of ADHD” as a single great insight, and then there’ll be a Nobel Prize waiting round the corner. But here

*"ADHD is bad luck for the individual, but may be an advantage for society," says Dr Jonathan Williams.*

# nges for the scientific process

they overlook the crucial detail, that most psychiatric disorders are so highly multifactorial, that each one will share its causes with other disorders, and with perfectly "normal" people. Comparisons of people who meet criteria for one disorder, against people who don't, will never succeed in finding a sole, or even a major, cause. Refining the definitions of disorders cannot solve this problem, but addressing the contributory factors one-by-one can," Williams believes.

**A machine that does not run smoothly**

A patient with ADHD has a problem with certain functions of the brain, and it may help to compare this to a car engine that does not run smoothly. "The engine may have a dirty carburettor, defective sparkplugs, worn pistons, and so on. Today's ADHD research can be compared to a form of engine research in which competing groups of researchers each study their own theory that one of these problems alone explains the whole. Instead, they should by thinking about how combinations of mild problems, or idiosyncracies, interact to cause the whole. What's more, the human brain is vastly more complicated than a car engine," Dr Williams points out.

"It's not very useful to have one model to explain why ADHD is more common in boys, a second model to explain why children are more susceptible than adults, a third model to account for why five per cent of the population are affected, and so on. We need a model which includes all these aspects and which describes the fact that there can be many different causes that are additive or interactive," Dr Williams believes.

Williams finds support for his views in the work of the American psychiatrist Kenneth Kendler, who in March 2005 published a report strongly attacking the notion that psychiatric disorders can have a single core cause. "Researchers in the field of psychiatry have hitherto used models that are too simple. In this area geneticists have in fact been wiser, because their methods prevent them forgetting the interaction of many different genes involved in ADHD. None of the genes represents a simple explanation, but each variant gene increases the probability of developing ADHD," Williams explains.

before making this claim, and he has discussed other possible explanations in a research report together with Professor Eric Taylor. The report includes computer simulations of the survival of societies with differing rates of ADHD in the population.

**Others learn from their mistakes**

"There are some practical benefits of having a child with ADHD in your class or village. The other children will know what will happen if you stand up and walk around in class. They will also know what happens when someone falls out of a tree, and they will see how ill people can get when they eat something they shouldn't," explains Dr Williams.

"It has been shown that children with ADHD, who are treated for it, have better lives with better jobs and they are less likely to get in trouble with the law. But then comes a difficult question: if we help the ADHD children, do we need extra educational or social measures for all children, to replace the lost demonstrations of mistakes?" asks Dr Williams.

## CAS researcher awarded prize for outstanding research

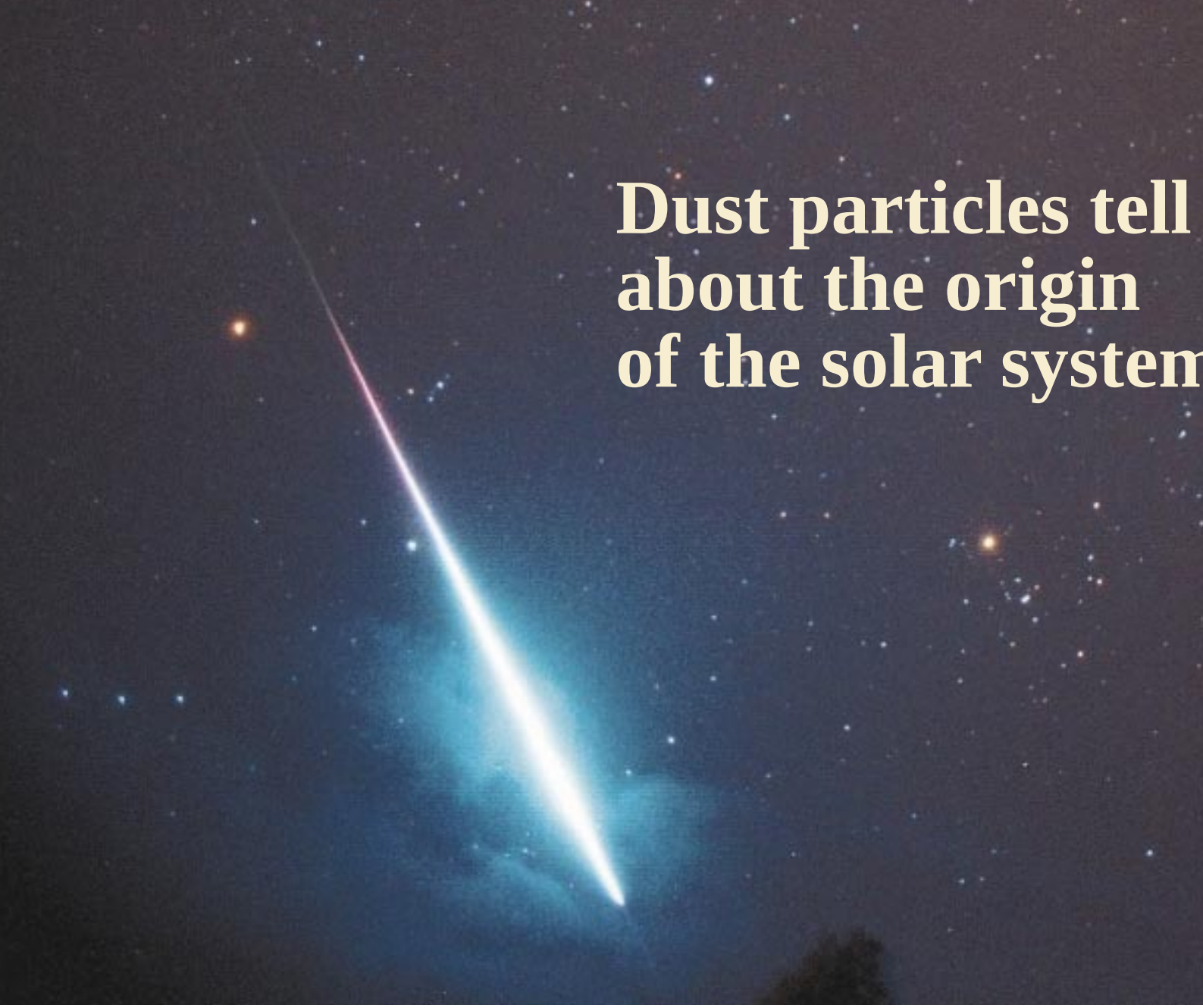
**In 2004 the Norwegian Research Council's Prize for Outstanding Research – the Möbius of the Year – was awarded to the mathematicians Erling Størmer and Ola Bratteli. Professor Bratteli was affiliated to the CAS in the autumn of 2001, and says that academically speaking his stay was extremely valuable to him.**

"My stay at the CAS was obviously valuable for my academic development. Among other things I spent the time completing a book together with my Dano-American colleague Palle Jørgensen, Ola Bratteli relates.

Professor Ola Bratteli

"I don't really know how it is in other subjects, but at any rate in mathematics it's very important to meet colleagues in the subject at institutions of the CAS type. Among other things one gets the chance to develop a larger network in the field, and I know of several instances in which researchers who have met one another in such circumstances have later written articles together," says Professor Bratteli.

In the autumn of 2001 Ola Bratteli was affiliated to the CAS research group "Non-commutative phenomena in mathematics and theoretical physics", which was headed by Magnus B. Landstad and Stein Arild Strømme. According to the Möbius jury, Ola Bratteli and Erling Størmer have greatly contributed to giving Norwegian mathematics the international status that it has today. The two were inter alia given special mention in an international evaluation of the Norwegian mathematics communities in 2002. Erling Størmer and Ola Bratteli are both Professors in the Department of Mathematics at the University of Oslo, a community that for a long time has been a centre of international research activity on a high level within the field of operator algebra.



# Dust particles tell about the origin of the solar system

Looking for a needle in a haystack may seem simple in comparison with Lars Dyrud's research. Dr Dyrud uses radar stations on the surface of the Earth to study meteors the size of dust particles at altitudes near 100 kilometres, as they rush into the atmosphere at speeds of around 50 kilometres per second. The aim is, among others, to find out more about the origin of the solar system.

"The radar stations we use are pretty sensitive. They can observe a coin at a distance of 100 kilometres, which means that they're also sensitive enough to see the traces of these meteors. The thing is, we can't see the actual meteors, because they melt and burn up immediately they come into the Earth's upper atmosphere. Instead we must resort to observing their trails," says Lars Dyrud.

Dr Dyrud and his colleagues on the research project *Using plasma turbulence to understand the global impact of billions of daily meteors* are using among other things the Scandinavian EISCAT radars and the Arecibo Observatory in Puerto Rico to study the traces of the dust particle meteors. It should be mentioned that the actress Jodie Foster used the Arecibo Observatory as a backdrop when she played the astronomer Eleanor Arroway in the film *Contact* from 1997.

At intervals of some million years, meteors arrive that are large enough to exterminate dinosaurs and threaten life on Earth. At intervals of roughly 100 years meteors arrive that are large enough to lay waste stretches of forest in Siberia, for example, while those meteors that are large enough to be observed as shooting stars may come several times every 24 hours. The meteors that Lars Dyrud is working on are, however, much smaller than all these. On the other hand there are very many of them.

## Lots of little meteors

"We don't know how many meteors penetrate the Earth's atmosphere, but it's probably a matter of several billion in the course of 24 hours. The vast majority are only the size of a particle of dust or a grain of sand, and estimates when it comes to mass vary between 10,000 and 200,000 tonnes per year. This is one of the motives for doing this research: we simply want to find out how much mass is involved," says Lars Dyrud.

"I suppose most of this no doubt gradually falls down onto the surface of the Earth. Does this mean that in the course of time the Earth is getting heavier on account of these thousands of millions of meteors?"

"The Earth is so large that this meteor dust represents perhaps a thousandth part of one per cent of the planet's mass in the course of a thousand years, so it's negligible. But the meteors obviously play a role when it comes to bringing dust and particles into the upper atmosphere. *What* they mean for the atmosphere is

us

*Lars Dyrud observes the traces of meteors much smaller than the ones we observe in the sky at night. They are about the same size as dust particles, at an altitude of 100 kilometres, and at speeds around 50 km/h. (Photo: Arne Danielsen/Scanpix, Maria M.L. Sætre, CAS)*

also a question we want to learn more about through this research project," Dr Dyrud replies.

The meteor dust is inter alia responsible for the nocturnally luminous clouds that can be observed from time to time in the Polar Regions. These clouds are typically found at an altitude of 80 kilometres and may have a climatic effect or indicate global change. "But our most important motivation for studying these meteors is that they can help us to learn more about the solar system. As long as we don't know how much dust enters the Earth's atmosphere, we don't know either how much dust is to be found out there in the solar system, nor do we know how it is distributed. This again means that we don't understand all aspects of how the planets and the solar system were formed," explains Lars Dyrud.

"For example, we don't know whether this dust comes from comets, whether it has been knocked off of other planets, or whether it is the remains of the dust that originally gave rise to the whole solar system," he adds.

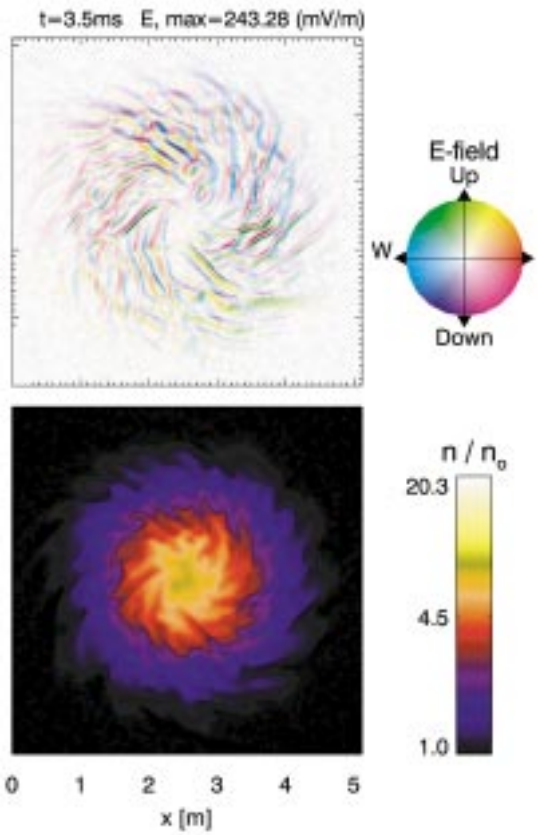
### Studying the plasma traces of the meteors

There is a great deal of knowledge about the composition of those meteors that do not burn up in the atmosphere but instead reach the surface of the Earth and are called *meteorites*. There is also a great deal of knowledge about those meteors of the size of pebbles which are common in meteor showers and emit a strong light while they are burning up in the atmosphere. The point is that different elements emit different colours during combustion, and the elements can be detected from far away by means of spectral analysis. "But the minute meteors we're hunting for don't emit sufficient light for us to be able to carry out spectral analyses. So we've had to find another solution," explains Dr Dyrud. And that solution makes the "needle in a haystack" problem seem trivial. When the meteors come in at great speed towards the Earth and begin to collide with the molecules in the atmosphere at an altitude of roughly 100 kilometres, they're subjected to enormous heating. They quickly reach a temperature near 2000 °C, which is the boiling point of many materials. This means that the surface of the dust particles boils and releases material in the form of gas, and this gas is immediately electrically charged (ionised) on account of the high speed. This again means that the meteors leave behind them a minute trace of ionised gas, in other words plasma, and this plasma trace is unstable and becomes turbulent. And plasma turbulence is, amazingly, a phenomenon that can be observed by radar at a distance of 100 kilometres. The use of large radar observatories for the study of meteor particles is a research field that has aroused renewed interest in the last decades, and Lars Dyrud's group are among the few researchers who have worked on the plasma turbulence aspect. They have made great progress and are now approaching the point at which they can use the radar signatures left by plasma turbulence to reveal the composition of the meteors. "After this we hope to be able to hand over the information we generate to solar system researchers, so that they can refine their models of how the solar system arose," Lars Dyrud predicts.

### Exotic guests from space

The speeds of the individual meteors can tell us a good deal about their origin. "Most meteors have speeds between 11 and 73 km per second. Earlier it was supposed that most meteors travelled at roughly 20 km/s, but now we can see that the majority probably travel at 50–60 km/s. The lowest speed – 11 km/s – is purely a function of the Earth's gravitation, and these meteors thus had no starting speed to speak of until they came into the atmosphere," says Dr Dyrud.
A couple of per cent of the meteors have speeds in excess of 73 km/s, and these are especially interesting guests. "The high speed tells us that these meteors come from areas outside the solar system. In other words we get materials from outside our own solar system coming into the atmosphere, and it's obvious that it's extremely interesting to find out what they consist of," says Lars Dyrud.

*The illustration shows a simulation of a plasma trace left by a dust particle meteor. The top illustration shows the electrical field in colour, while the bottom illustration shows the density of the plasma.*



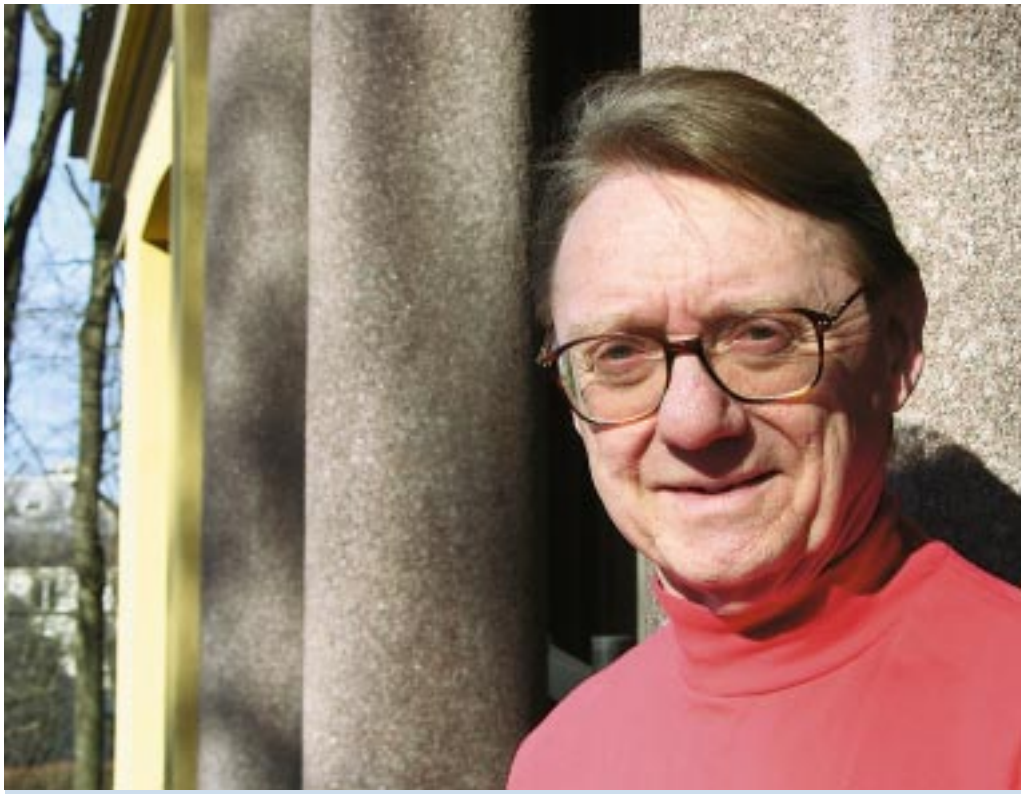

## Research on turbulence in plasmas and fluids

■ Lars Dyrud is a post-doctoral research fellow in the Department of Astronomy at Boston University in the USA. For the period 2004–2005 he is also a member of the CAS research group *Turbulence in plasmas and fluids*, headed by Professor Jan Trulsen from the Department of Astrophysics and Professor Hans L. Pécseli from the Department of Physics at the University of Oslo.

Plasma can be described as a gas that has been supplied with so much energy that first the molecules and then the atoms are split into free positive ions and negative electrons. Plasma is inter alia a powerful electrical conductor.

# Linguistic changes originate in ind

When languages change, every large or small change is in the final analysis the sum of numerous small innovations made by individual speakers in individual speech acts. This means that individuals have some responsibility for the direction in which their language develops, says Professor Henning Andersen.



*– The language capacity is simply an incredibly important part of human nature, says Professor Henning Andersen.*

Henning Andersen is a professor of Slavic Linguistics at the University of California in Los Angeles, but is spending this academic year at the CAS as a member of a team investigating *Linguistic Theory and Grammatical Change*. The aim of their project is to develop new theories concerning the internal conditions for grammatical change. Linguists already know a great deal about how languages change, but through their work at the CAS this group hopes to gain a better understanding. Their point of departure is a set of concepts that can be used to describe all changes in language: *neologism, adoption* and *reanalysis*.

Most changes have their origin in a purposeful innovation made by an individual either in speech or in writing. The individual can either devise a new word or expression to satisfy a communicative need or use an existing expression in a new way. If such a neologism is adopted by enough members of the speech community, the result will be a linguistic change. We have in a sense a collective decision, says Andersen.

**Linguistic mutations**

The third concept, *reanalysis*, is somewhat similar to neologism and can be compared with the genetic mutations in biology that may give rise to new species if there are enough of them. Reanalysis is the reinterpretation of existing language expressions by individuals or by a whole generation of speakers. From an outsider's point of view it may seem that the expression is being misunderstood. But those who produce the reanalysis are not necessarily aware that they are making a new interpretation, says Andersen.

The Latin word *rarus*, meaning "rare", is

# Numerals arrived with agriculture

**The reason there are so many languages is that different peoples have different histories. Linguists can observe clear traces of the dramatic cultural change that happened some 10,000 years ago when the first people changed their way of life from hunting and gathering to farming.**

This change occurred in the Middle East – in areas that are now parts of Iran, Iraq and Syria – and entailed among other things the rise of a need for numeral expressions. Before, say, 10,000 years ago there were probably no languages that had numerals, for there were only hunter-and-gatherer cultures, says Henning Andersen.

In fact even today there are some languages that lack numerals, or have no numerals beyond "one", "two", and "three", all of them spoken in simple cultures of hunters and gatherers. We find them, for instance, in the Amazon Basin in Brazil, in Australia, in New Guinea, and a few other places such as the Andaman Islands.

– These are cultures that have subsisted to the present day without ever developing the vocabulary necessary for trading – for you cannot trade unless you have numerals. These languages do have quantifiers such as "much", "little", "nothing" – these are probably universal. But languages such as Dani in Papua and Piraha in Brazil have only these very general terms. Some other languages have "one", "two", and "three", but have no way of expressing larger precise quantities.

The development of numerals in the Middle East some 10,000 years ago formed the basis for the origin of mathematics. – But we should be cautious and not think of commerce as the *only* impulse to the development of numerals. Counting systems may also have religious significance and be tied to the need to develop calendar systems. But in every case where we have evidence of the development of numerals, we are dealing with a culture that has made the transition to agriculture, he adds.

# ividuals

the source of the English word *rare*, which has kept the original meaning. But in Danish the word *rar* has developed the meaning "nice, friendly", and in Norwegian, *rar* means as much as "strange". The different meanings of these words may originally have been variants of "rare", but through reanalysis they have been separated from the meaning "rare".

**Changes originate in individuals**

Neologism, adoption and reanalysis are innovations made by individuals, and that means that individual members of a speech community have some power to influence the development of their language. "To take an example, if you don't like the fact that a lot of English words are being introduced into Norwegian, you have a right to try and do something about it. The least you can do is to avoid them and use Norwegian words instead," says Andersen.

"As a linguist I have two ways of looking at such questions. For a linguist it is extremely interesting to observe how linguistic change takes place. As a linguist you naturally adopt a clinical, neutral attitude vis-à-vis such processes. But at the same time, if you are a member of a speech community and a bearer of its linguistic norms, you have both a right and an obligation to take a stand on whatever changes are taking place. The first loanwords that enter a language are often viewed as an enrichment of it. But if too many foreign elements are introduced, the language will lose its identity and may die. So if you think it's a bad thing that, for instance, English and American words and expressions are making inroads into Norwegian, you have a right to oppose this development." And in fact, individuals can play a role in language development, in Andersen's opinion.

**Our capacity for language is innate**

Even though there are thousands of languages, linguists emphasize the similarities that unite all languages. All languages have vowels and consonants, nouns and verbs, and they form sentences in similar hierarchically structured ways. "We are all born with a capacity for language, what some people call a universal grammar, which enables us to analyse speech and acquire a language. The most important task for linguists is to uncover the premisses we use in acquiring our language. There is no doubt that they are in our genes," says Andersen.

Still there are remarkable differences between the linguistic capacities of different individuals. Some have a great ear for language and may develop into poets, others have different linguistic gifts and become politicians or car salesmen. At the same time it is important to note that even deeply retarded children can learn to speak. The language capacity is simply an incredibly important part of human nature."

## The Centre for Advanced Study

The Centre for Advanced Study at the Norwegian Academy of Science and Letters is an independent foundation with a board appointed by the Academy, the Universities and Colleges Council and the Research Council of Norway. The intention is that the academic activity at the Centre shall be recognised as achieving the highest international standard and thereby contributing to raising the quality of basic research and interdisciplinary research in Norway. The academic activity at the Centre is of a long-term nature, and is to be permanent and academically independent vis-à-vis political and economic influences and the influence of research policy.

Outstanding researchers from Norway and abroad are invited for one-year stays in the Centre's premises in the Academy's villa in Drammensveien in Oslo.

Each year the activity is organised in three research groups, each with from six to ten members with long-term affiliation. In addition come numerous researchers for stays of shorter duration. Each group is planned and organised within a unifying theme and headed by one or more outstanding researchers.

The groups are chosen from each of the following three subject areas:

- The Humanities/Theology
- Social Sciences/Law
- Natural Sciences/Medicine/Mathematics

The Centre is exclusively a basic research institution where the participants have no other obligations than their own research. The Centre is administered by a permanent staff of four and was officially opened on 1 September 1992.

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# ADHD: A question of poor *timing?*

Current scientific thinking indicates that the core behavioural symptoms of ADHD – difficulties in concentrating, restlessness, impulsiveness – are linked to poor regulation of dopamine and disturbances in the prefrontal cerebral cortex and striatum. Associate Professor Rosemary Tannock is working on a completely different theory that may come to alter the understanding and treatment of children and young people with ADHD.

*"There's a lot to suggest that children with ADHD have brains that cannot time action and thought as precisely and reliably as those without ADHD" says Rosemary Tannock.*

"Over the past few years we've had a number of research results to suggest that the underlying cause of ADHD may not be found in the frontal cerebral cortex, but instead in the cerebellum. The cerebellum plays an important role for the fine control of movements and precise timing of actions, sound discrimination, and thought. The first signs that the 'prefrontal lobe and dopamine theory' did not tell the whole story came when a group of researchers from the National Institute of Health in the USA published a report that showed that the cerebellum was smaller in size in ADHD children compared to "normal" children", says Rosemary Tannock. She is a Senior Scientist at The Hospital for Sick Children, an associate professor in the Department of Psychiatry at the University of Toronto in Canada, and a member of the ADHD research group at the CAS.

## ADHD children are actually slower

"The description of ADHD children as unable to concentrate, hyperactive and impulsive doesn't account for the observation that they are frequently clumsy – bumping into chairs, tables, other people – and in general are not in synchrony with their environment. Children with ADHD may move too quickly or too slowly, they talk too loudly or too softly, they interrupt but also may not respond in a timely manner, and so on. This type of behaviour might reflect motor timing problems rather than poor concentration or hyperactivity," says Rosemary Tannock.

"It is in addition a myth that children with ADHD are 'hyper and quick' in responding. When we measure their response times, in reality they are very much slower and more variable than other children. Also, in everyday life, they have major problems making rapid adaptations to the changing conditions in their surroundings".

"So this lead me to pose the question – do individuals with ADHD have difficulties processing information about time? In other words, do they have difficulties being able to predict exactly when an anticipated and predictable event will occur and exactly how long it will last?

## Measuring time perception

Rosemary Tannock has designed and performed a series of experiments that illuminate the proposed connection between ADHD and timing problems in the cerebellum. She measured the precision with which children and adolescents could distinguish different short time intervals from one another, and it turns out that children and adolescents with ADHD achieve significantly poorer results than other children. If for example you ask a boy with ADHD to follow the beat from a metronome, he will take longer to pick up the correct beat. And if the metronome is turned off, he will lose the rhythm much more rapidly than other children.

"Timing problems is something quite different from motoric hyperactivity, concentration problems, or to being unmotivated to work and behave appropriately. If we can substantiate this idea with good data, this is a way of thinking that teachers, parents and others must take into account in contact with these children. Of course the next critical question would be how can we help these youngsters. Our preliminary work suggests that the current pharmacological treatment does not help these type of timing problems", Rosemary Tannock asserts.

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