The Erwin Schrödinger International Institute for Mathematical Physics

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ESI NEWS

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Editorial

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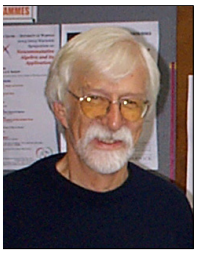

As many readers of this newsletter will know already, the year 2010 was 'interesting' for the ESI.

Scientifically, the second half of this year continued very well. The programme *Matter and radiation*, organized by V. Bach (Mainz), J. Fröhlich (ETH Zürich) und J. Yngvason (Vienna) ended on July 31. Its subject matter was the quantum mechanical description of non-relativistic matter, with about 50 participating scientists.

From early June until August 15 the programme *Topological String Theory, Modularity and Non-Perturbative Physics*, organized by L. Katzarkov (Vienna), A. Klemm (Bonn), M. Kreuzer (Vienna) and D. Zagier (Bonn), focussed on topological properties of gauge- and string theories, which are the basis of our understanding of particle physics and quantum gravity. The programme brought together experts on the theory and application of automorphic forms, on techniques for solving the integrable structures as developed in statistical mechanics and matrix models, and on application of these techniques to the study of non-perturbative contributions to the effective action of string- and gauge theory models. Almost 60 mathematicians and mathematical physicists participated in this programme, which also contained workshops on *D-branes, effective actions and homological mirror symmetry* and *topological strings, modularity and non-perturbative physics*.

The programme *Anti – de Sitter holography and the quark-gluon plasma: analytical and numerical aspects* was organized by A. Rebhan (Vienna), S. Husa (Univ. Illes Balears, Spain) and K. Landsteiner (IFT Madrid, Spain) and ran for three months from August – October 2010. This programme studied quantum chromodynamics (QCD), the theory of the strong nuclear interactions and focussed on the theory behind some of the expected – and some unexpected – properties of the state of matter in heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory in the USA, for example. Two workshops were part of this programme, one on *AdS holography and the quark-gluon plasma*, and one on *Hot matter*. More than 100 participants visited the ESI for various periods of time during this activity.

The last thematic programme in 2010 was *Higher structures in mathematics and physics*, organized by A. Alekseev (Geneva), H. Bursztyn (IMPA, Rio de Janeiro, Brazil) and T. Strobl (Lyon). This programme ran from the beginning of September until early November 2010 and focussed on recent geometrical developments studied by mathematicians and mathematical physicists. The three main topics were *Generalizations of symplectic and Poisson geometry*, *Higher degree graded manifolds, higher gauge theories and gauged supergravity* and *Quantum groups and quasi-Hopf algebras, Drinfeld associators and applications to low dimensional topology*. The programme had more than 100 participants and contained a series of minicourses on topics like *Higher gauge theories*, *Supergeometry and differential graded manifolds*, and *Gauged super gravity*.

In addition to these major research programmes and their workshop there were a number of independent shorter workshops at the ESI during the second half of 2010, as well as a *Senior Research Fellows Lecture Course* on *Representations contributing to Cohomology of Arithmetic Groups*

by T.N. Venkataramana (TIFR, Mumbai).

Details of all these activities can be found on the ESI web pages.

As one can see, the scientific activities of the ESI in 2010 were more than satisfactory. In other respects, however, the year 2010 had a sting in its tail, to use a popular literary expression:

The end of the ESI as an independent institute.

Things started harmlessly enough. On July 27, 2010, the Minister of Science, Dr. Beatrix Karl, visited the ESI and afterwards sent out a glowing press release about the work done by the Institute (in German: translation would not do the content justice):

Beatrix Karl: Mobilität und Nachwuchsförderung werden am Erwin-Schrödinger-Institut groß geschrieben

Wissenschafts- und Forschungsministerin Dr. Beatrix Karl hat heute das Erwin-Schrödinger-Institut (ESI) in der Wiener Boltzmanngasse besucht. "Das Erwin-Schrödinger-Institut ist auf dem Gebiet der mathematischen Physik und Mathematik weltweit führend und wurde für Wissenschafter und Forscher aus der ganzen Welt zu einer wichtigen Forschungs- aber auch Begegnungsstätte", so die Ministerin. Besonders erfreulich sei der rege Austausch, kommen doch jährlich mehr als 500 Wissenschafterinnen und Wissenschafter aus der ganzen Welt an das Institut nach Wien. "Wissenschaft und Forschung am Erwin-Schrödinger-Institut profitieren von dieser Mobilität der Forscherinnen und Forscher, das stärkt auch den Standort Wien", betont Karl. Das Erwin-Schrödinger-Institut bildet auch einen zentralen Schwerpunkt der Ministerin ab: die Nachwuchsförderung. 2004 initiierte das Bundesministerium für Wissenschaft und Forschung (BMWF) das "Junior Research Fellows"-Programm, es wird jährlich mit rund einer Million Euro gefördert. Junge Doktoranden und Postdocs können dadurch für ein Semester am Erwin-Schrödinger-Institut forschen. Der Frauenanteil liegt dabei bei bis zu 40 Prozent. "Die Nachwuchsförderung ist für den Wissenschafts- und Forschungsstandort Österreich zentral. Gerade im Bereich der Mathematik, aber auch der Informatik, Naturwissenschaften und Technik ...", so die Ministerin zur geplanten Info-Offensive in diesem Bereich.

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Readers familiar with the German language will notice the frequent references to the importance of *Nachwuchsförderung*, i.e., of support and training of young scientists (postdocs and PhD students).

Since 2004 the ESI had been running a 'Junior Research Fellows' (JRF) Programme for advanced PhD students and postdocs to allow them to participate in the activities of the ESI. This programme was about to come to an end in early 2011. We (the directors of the ESI) discussed this with Dr. Karl, who was very impressed by the JRF Programme and suggested that we discuss options for its extension with one of her section heads.

We met the section head responsible on October 25, 2010 and were told there that the funding of the ESI would be ended with the end of 2010. In order to cover immediate commitments the ESI would be offered about 40% of its basic annual budget as a one-time payment for 2011. Hope was expressed that the ESI could be saved by becoming part of the University of Vienna.

The ESI was one of more than 70 scientific institutions affected in this manner. The criteria for the selection of these institutions are completely mysterious. What is abundantly clear is that scientific excellence — or the lack thereof — played no part in the selection process.

I should not complain too much about this ill-considered, irrational and completely mismanaged attempt to save small amounts of money as part of a more general policy of cutting support for universities and other reputable scientific institutions. The ESI got off relatively lightly: thanks largely to the overwhelming response by the international scientific community (including numerous Fields-Medal and some Nobel Prize winners) to the imminent demise of the ESI, the Ministry of Science has agreed to provide basic funding to the ESI for the years 2011 – 2014, and possibly until 2015, at the same level as in 2003, without any compensation for inflation since then. This funding will not go to the ESI directly: the Institute will become part of the University of Vienna, through which the funding for the ESI will be channeled.

What is unfortunate, but completely in line with the government's attitude to higher education and scientific training, is that the highly successful JRF Programme of the ESI will be suspended from early 2011 due to lack of funding. It is worth reflecting on this in the light of the ministerial press release from July 27, 2010.

The 'rescue' of the ESI as part of the University of Vienna will bring financial security (at a reduced level), and — at least in the short term — allow the institute to continue operating, perhaps even at a reasonable level of independence. In the long run, however, the chronically under-funded university will put pressure on the institute to churn out graduates and reduce its budget for visitors. *In the first year, the Erwin Schrödinger Institute may be seen as a gift to the university by the Ministry of Science, but in the following years it will be just another player in a zero sum game whose rules will not be conducive to the needs and priorities of a research institute operating at an international level*. It is a clear portent for the future that the University is not prepared to provide funding for a continuation of the ESI JRF Programme from 2011.

In late 2010 neither the Ministry of Science nor the University of Vienna can afford to take the blame for the closure of the ESI. By 2014 or 2015 the picture may look different, and the closure of a down-at-heel ESI may then be seen as justified.

Correlators in deSitter spacetime and the 'heat death' of the Universe

Stefan Hollands

Questions about the origin of our universe belong to the deepest and most intriguing in all of science. Most people now believe that the universe was created in the "big bang", and much progress has been made in understanding the physics of this event. However, we are still very far from—and may never attain—a complete understanding, due mostly to the unsurprising difficulty in reconstructing from present observations an event some 14,000,000,000 years in the past, and also due to our still patchy understanding of the microscopic physical laws that governed it. There are similar difficulties in answering the equally intriguing question about the ultimate fate of the universe. Since we cannot travel into the future, we need to know as best as we can the present conditions of the universe, and the dynamical laws that govern its evolution on large scales, so that we might be able to extrapolate what will happen in the future. Again, it is not clear that we understand this well enough yet.

Nevertheless, there is much to be learned from applying established physical theories to cosmology, and push their range of validity as far as one may reasonably expect to be allowed to. At large scales in space and time, the physical fields present in the universe are describable by classical field theory and the relevant field equations are Einstein's equations,

$$\mathrm{Ric}(g) - \frac{1}{2} g\, \mathrm{Scal}(g) = 8\pi\, T\ . \tag{0.1}$$

The gravitational field is encoded in a metric g on a 4-dimensional spacetime M, and the terms on the left side are the Ricci-tensor and scalar curvature formed from this metric. The matter fields present in the universe enter the stress energy tensor on the right side. For example, for a Maxwell field, the components (T_{01}, T_{02}, T_{03}) represent the Poynting vector of the electromagnetic field at a point relative to some orthogonal frame, T_{00} represents the energy density of the electromagnetic field, etc. Thus, according to Einstein's equations, a non-zero stress tensor has an effect on the metric. Although the equations are highly complex, solutions can readily be obtained if e.g. the metric and matter fields are assumed to be isotropic and homogeneous in space, as appears to be consistent on large scales with observations. The metric then (by assumption) has the Friedmann-Robertson-Walker (FRW) form[1]

$$ds^2 = -dt^2 + a(t)^2(dx^2 + dy^2 + dz^2)\ , \tag{0.2}$$

where the function $a(t)$ describes the expansion (or contraction) of the universe. It is determined by Einstein's equation once we say what is our model for the stress tensor. To the surprise of many scientists, observations pioneered over the past decade have given strong indications that, for some time now, the dominant contribution to the stress tensor has been of a form that can be modeled quite well by what is arguably the simplest possibility, namely a "cosmological constant", $T = -\Lambda\, g$, see e.g. [6]. More explicitly, in an orthogonal frame, T is diagonal with positive energy density $T_{00} = \Lambda$, and negative pressures $T_{11} = T_{22} = T_{33} = -\Lambda$. The corresponding FRW-metric is

$$ds^2 = -dt^2 + \mathrm{e}^{2tH}(dx^2 + dy^2 + dz^2)\ , \tag{0.3}$$

known as "deSitter spacetime", where $H^2 = 3\Lambda$ is known as the "Hubble parameter". Thus, our universe expands at an exponential rate. If this type of expansion were to go on in the future, one might expect that, eventually, all remaining gradients in the matter distribution (which ought to be viewed as resulting in "perturbations" on top of the above FRW-metrics) will be washed out at least locally, leading to what has been called the "heat death" of the Universe.

Quite amazingly, many cosmologists believe that another era of exponential expansion (characterized by a vastly bigger Hubble constant H on the order of the energy scale of elementary particles) took place at or very shortly after the beginning of the universe, creating a big universe such as ours from some kind of small seed. This hypothetical scenario is generally called "inflation". There exists a host of different suggestions what was the precise mechanism that caused–and ended–this inflationary phase, and whether it is e.g. related to the present phase of accelerated expansion or not. A plausible guess is that a quantum theory of gravity will ultimately have to be invoked to answer this question, if inflation indeed ever happened. At any rate, if the universe underwent such a phase of exponential expansion at or shortly after its beginning, then again, any details about the nature of the initial state, presumably determined in some way by quantum gravity, will very rapidly be washed out. *So we are saved because we do not need to know precisely what exactly this unknown state was for subsequent calculations!* Indeed, great advantage is taken of this basic hypothesis in the explanation of many important effects in cosmology, such as the explanation and calculation of the spectrum of "primordial fluctuations", directly linked in turn to the angular distribution of temperature seen in the cosmic microwave background (CMB), see e.g. [15]. To explain these fluctuations, and of course for many other purposes, it is necessary to have a theory incorporating also the quantum nature of matter.

[1] This is an FRW-spacetime with flat slices $\mathbb{R}^3$, a model which currently seems to be favored over ones with spherical or hyperbolic slices.

The most accurate such microscopic theory of matter that we have to date is quantum field theory (QFT). It is the synthesis of the dual particle- and wave nature of quantum mechanical objects, and the principles of relativity. The quantities one aims to calculate or characterize in this kind of theory are the correlation functions of the quantized field(s) in some state such as $\langle\phi(x_1)\dots\phi(x_n)\rangle_\Psi$. The angles represent the expectation value, in some state Ψ, of the product of fields. Each field can be thought of, informally, as an operator that is parameterized by a spacetime point. Depending on the model, the field(s) of the theory can describe scalar particles, spin-$1/2$-particles, gauge bosons etc. Gravity has as yet not be incorporated in this framework, but one can consider quantized gravitational perturbations off a given background (such as an FRW-metric), or leave those aside and consider QFT's without a dynamical gravitational field on a rigidly fixed, curved background.

Most often, of course, QFT's are considered in flat Minkowski spacetime. In this spacetime, a reasonable QFT is expected to have a distinguished state, called "vacuum", represented by a vector called $|0\rangle$ in a Hilbert space of states on which the field operators can act. From this vacuum, one can often build incoming or outgoing "particle states" by applying suitable operators built from fields to $|0\rangle$. Properties of particles, collision processes, etc. can then be described by matrix elements formed from such states, which in turn can be related directly on the one hand to vacuum correlation functions $\langle\phi(x_1)\dots\phi(x_n)\rangle_0$, and to scattering experiments on the other hand. Over the years, methods have been developed to calculate such quantities in perturbation theory starting from a classical Lagrangian that specifies a given theory, and great progress has been made in determining which Lagrangian(s) accurately describe the fields (particles) that are found in Nature. The culmination of this efforts has been the construction of the "standard model Lagrangian" together with the associated rules for calculation correlation functions etc.

Unlike Minkowski spacetime, a *generic* curved spacetime will simply not have any isometries analogous to spacetime translations. For example, time translations are not a symmetry of of the FRW-metrics (0.2) for nontrivial functions $a(t)$. In the absence of such a symmetry, it is impossible to define a conserved Hamiltonian, and therefore clearly likewise impossible to define in a reasonable way ground states, particle states etc. However, the correlation functions for any state Ψ may still be computed. These correlation functions can, as in scattering experiments, often be directly related to experiments. For example, in deSitter spacetime, the "equal time" Fourier transforms

$$\delta^3\left(\sum_{j=1}^n \mathbf{k}_j\right) w_n(t;\mathbf{k}_1,\dots,\mathbf{k}_{n-1}) := \left(\prod_{j=1}^n \int_{\mathbf{k}_j} e^{i\mathbf{k}_j\cdot\mathbf{x}_j}\right) \langle\phi(t,\mathbf{x}_1)\cdots\phi(t,\mathbf{x}_n)\rangle_\Psi \tag{0.4}$$

are directly related[2] to the multi-point temperature correlation functions in the CMB, if t is taken a suitable time in the history of the cosmos, and $k_j/a(t) \ll H$, and ϕ is a suitable quantum field[3]. For the reasons mentioned above, one might expect that it does not matter too much what state Ψ we use in this calculation (it should respect the translational symmetry of the deSitter metric in spatial directions though).

To check this, one should look at the large t behavior of deSitter correlators $\langle\phi(t,\mathbf{x}_1)\cdots\phi(t,\mathbf{x}_n)\rangle_\Psi$, and see to what extent they become "universal", i.e. independent of t. For example, the statement about the 1-point function that

$$\langle\phi(t,\mathbf{x})\rangle_\Psi = O(e^{-Mt}) \tag{0.5}$$

for large $t\to\infty$ for some $M>0$ could be viewed as saying that quantum fields decay exponentially at infinity in *any* state! It would be a mathematical version of the statement that amplitudes of fields in the universe disappear, leading to the "heat death". [Note that this behavior is qualitatively different from that of a massive quantum field in Minkowski space, where the fall-off is shown to be $\langle\phi(t,\mathbf{x})\rangle_\Psi = O(t^{-\alpha})$ in generic states.] An analogous statement for the stress energy operator T instead of ϕ would indicate the IR-stability of the deSitter spacetime. In the same spirit, an analogous result for the perturbations of the graviton field, with the appropriate value of M, could be viewed as a quantum analog of a "cosmic no-hair theorem", which roughly speaking can be stated as saying that, locally, perturbed metrics will approach deSitter spacetime, regardless of the initial condition. In this letter, we will explain to what extent these statements are actually known to be true in a concrete quantum field theory model.

However, to put things into perspective, we would first like to discuss briefly the general question when one should expect QFT in curved spacetime to "behave qualitatively different" from flat spacetime. Roughly speaking, when the points $x_1,\dots,x_n$ are a distance or proper time apart which is not larger than the "curvature radius" (the "typical" magnitude of appropriate negative powers curvature invariants such as $\mathrm{Scal}(g)$ near these points), then one expects intuitively that the behavior of correlation functions in a generic state will not be substantially different from a "corresponding" state in Minkowski spacetime. [In deSitter spacetime, on which we will focus from now on, the curvature radius is simply H^{-1} everywhere since it is a space of "constant curvature".] This statement can be made somewhat more precise via the operator product expansion, which states that for any set of—possibly composite—field operators denoted ϕ_A, we have for $x_1,\dots,x_n\to y$,

$$\langle\phi_{A_1}(x_1)\cdots\phi_{A_n}(x_n)\rangle_\Psi \sim \sum_B C^B_{A_1\dots A_n}(x_1,\dots,x_n;y)\ \langle\phi_B(y)\rangle_\Psi\ . \tag{0.6}$$

[2] Physical observables such as the quantities $|C_{lm}|^2$ describing the angular temperature fluctuation corresponding the spherical harmonic number lm are obtained e.g. from $w_2(t,\mathbf{k})$ integrating this against a suitable kernel $K_{lm}(\mathbf{k})$.

[3] At the linearized level, ϕ is a "gauge invariant" combination of the perturbations of the metric and inflaton fields [15].

Each coefficient $C^B_{A_1\dots A_n}$ itself is known [9], at least in perturbation theory, to have an expansion in terms of the geodesic distance between the x_i and curvature invariants at y. Thus, for distances or proper times much less than the Hubble radius (and masses greater than H), the coefficients will essentially be equal to those in Minkowski spacetime. As a consequence, for a state Ψ on deSitter such that the form factors $\langle\phi_C(y)\rangle_\Psi$ at point y are approximately equal to those of a corresponding state on Minkowski spacetime, the deSitter 2-point correlation function will not essentially differ from the Minkowski correlation function of that state near y. Thus, in this sense, one does not expect large departures of deSitter correlators from corresponding Minkowski correlators at small distances. Actually, as pointed out by [5], by analyzing which *Minkowski space* states will approximate the form factors of the corresponding fields in a state Ψ on *curved space*, we can also obtain their local physical interpretation: Pick a set of composite fields $\{\phi_A\}_{A\in I}$ where I is some finite index set, and consider the set of all thermal (KMS) states $\langle\,.\,\rangle_\beta$ on *Minkowski space* each characterized by a time-like vector $\beta\in\mathbb{R}^4$, whose length is the inverse temperature, and whose orientation determines the rest-frame of the thermal bath. Then, if for a given $y\in M$ we have

$$\langle\phi_A(y)\rangle_\Psi = \int_\beta \rho_\beta\,\langle\phi_A(0)\rangle_\beta\,, \quad \text{for all } A\in I, \tag{0.7}$$

for some distribution function $\beta\mapsto\rho_\beta\in\mathbb{R}_+$, then, as explained in [5], the state Ψ on curved space can be given a thermal interpretation locally near y.[4]

For large distances, however, these considerations do not apply and correlators can show an unexpected behavior totally different from Minkowski spacetime. For deSitter spacetime, this has been discussed by many authors in the literature, and for various theories, see e.g. [18, 7, 8, 16, 2, 14], with partly contradicting claims. The simplest theory one can study is that of a free, minimally coupled Klein-Gordon field ϕ with mass parameter m^2 and classical Lagrangian density

$$L = \frac{1}{2}[g(\nabla\phi,\nabla\phi)+m^2\phi^2]\,d\mu\,. \tag{0.8}$$

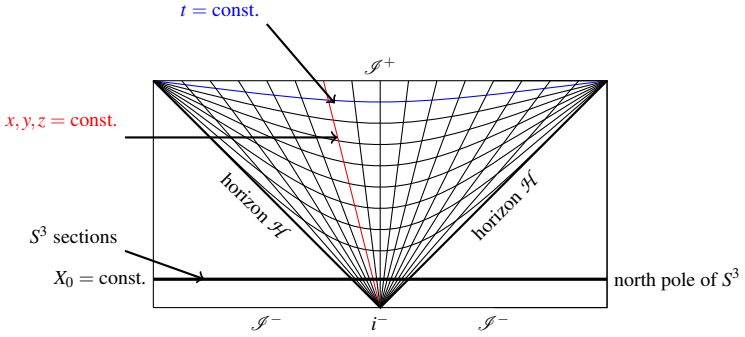
When the mass parameter is strictly positive, then there exists a unique deSitter invariant Hadamard-state [1, 14, 3], sometimes called "Bunch-Davies-" or also "Hartle-Hawking-" or "Euclidean-" state. The expression for the correlation functions of this state becomes much simpler if we introduce the coordinates

$$\begin{aligned} X_0 &= H^{-1}\sinh Ht - \frac{1}{2}He^{tH}r^2\\ X_1 &= e^{tH}x\\ X_2 &= e^{tH}y\\ X_3 &= e^{tH}z\\ X_4 &= H^{-1}\cosh Ht + \frac{1}{2}He^{tH}r^2\,, \end{aligned}$$

in terms of which deSitter space is simply the embedded hyperboloid

$$M = \{X\in\mathbb{R}^5 \mid X\cdot X \equiv -X_0^2+X_1^2+\dots+X_4^2 = H^{-2}\}$$

in a fictitious 5-dimensional Minkowski spacetime, with the induced metric. The original coordinates (0.3), often called "cosmological chart", actually cover only "half" of this hyperboloid, as indicated in the following conformal diagram:



The two-point function of the Euclidean vacuum is then given by [1, 3]

$$\langle\phi(X_1)\phi(X_2)\rangle_0 = \frac{H^2}{(4\pi)^2}\Gamma(-c)\Gamma(c+3)\;{}_2F_1\left(-c,3+c;2;\frac{1+Z}{2}\right), \tag{0.9}$$

[4] For example, in a flat universe but with toroidal topology $\mathbb{R}\times T^3$, the expectation value of composite operators in the ground state would be of order $L^{-\Delta}$, where Δ is the dimension of the operator, and L is the identification length $T^3=\mathbb{R}^3/(L\mathbb{Z})^3$. These quantities would vanish in the Minkowski vacuum, so the "corresponding Minkowski state" should be another state e.g. a superposition of suitable thermal states.

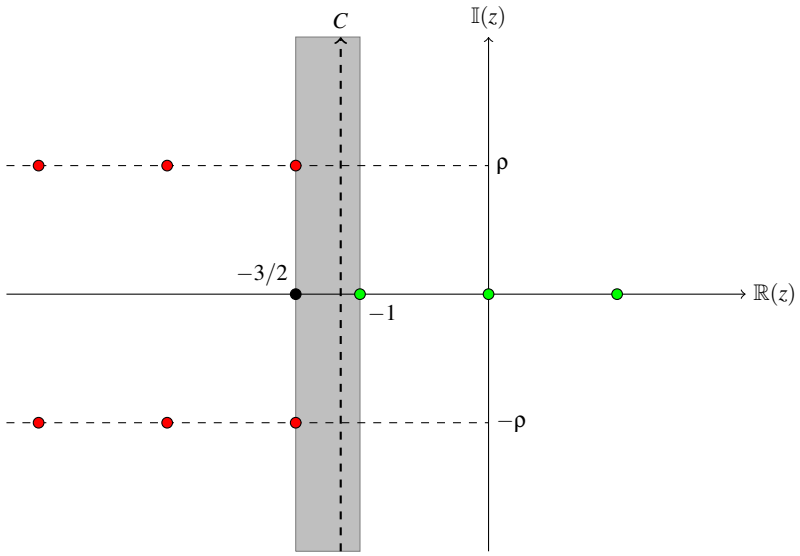
where $Z = H^2 X_1 \cdot X_2$ is the "point-pair invariant," and where the dimensionless constant c is defined by

$$c = -\frac{3}{2} + \sqrt{\frac{9}{4} - \frac{m^2}{H^2}} \tag{0.10}$$

As with any correlation function, this is distributional in nature, so it needs to be defined with some care as the boundary value (in the distributional sense) of an analytic function. The higher n-point functions are obtained by "Wick's theorem". To obtain the behavior of the correlators for large time- or spatial separations, one may use a Mellin-Barnes representation [12, 13]

$$\langle \phi(X_1)\phi(X_2)\rangle_0 = K_c \int_C \frac{dz}{2\pi i} \left(\frac{H^2(X_1 - X_2)^2}{4}\right)^z \frac{\Gamma(3+c+z)\Gamma(-c+z)\Gamma(-z)}{\sin(\pi z)\,\Gamma(2+z)} \,. \tag{0.11}$$

Here, K_c is a constant, the contour C is parallel to the imaginary axis near infinity, and it leaves the poles $-1+\mathbb{N}_0$ and $\mathbb{N}_0$ to the right, whereas it leaves the poles $c-\mathbb{N}_0$ and $-(3+c)-\mathbb{N}_0$ to the left. The contour C is visualized in the following figure, where we assume for simplicity that we have a "principal series scalar field" (meaning that $c = -3/2 + i\rho$, or $m^2 \geq \frac{9}{4}H^2$):



For timelike related X_1 and X_2, we have $H^2 X_1 \cdot X_2 = \cosh(Ht) \sim \mathrm{e}^{H|t|}$, where t is the proper time separating the points. Moving the contour as far to the left as we can without crossing the pole at $-3/2$, we immediately see that

$$\langle \phi(X_1)\phi(X_2)\rangle_0 = O(\mathrm{e}^{-\frac{3H}{2}|t|}) \,, \quad \text{as } |t| \to \infty, \tag{0.12}$$

and a similar bound also holds for the n-point functions by Wick's theorem. Furthermore, letting the GNS-Hilbert space vector representing the deSitter invariant state be $|0\rangle$, we may form a class of new states

$$|\Psi\rangle = \sum_n \int_{X_1,\ldots,X_n} f_n(X_1,\ldots,X_n)\; \phi(X_1)\ldots\phi(X_n)\; |0\rangle \tag{0.13}$$

by applying a smeared product of operators to it, where the f_n's are smooth smearing functions on the deSitter manifold M vanishing outside some compact region. From the exponential decay of the n-point functions of $|0\rangle$, we get the decay (0.5) for the 1-point function in the state Ψ, with $M = 3H/2$. By the Reeh-Schlieder theorem [17] in curved spacetime, the class of such states $|\Psi\rangle$ is in fact *dense in the Hilbert space built upon* $|0\rangle$. *Therefore, this result states that the expectation value of* ϕ *indeed decays exponentially in time in generic states.* A similar statement also holds for higher n-point correlation functions, as well as for scalar fields which are not in the principal series, as long as $m^2 > 0$.

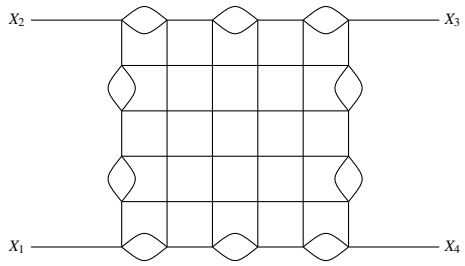
While this result was relatively easy to get for a free field, it is not so clear what might happen when an interaction is turned on, e.g. when we consider instead

$$L = \frac{1}{2}[g(\nabla\phi, \nabla\phi) + m^2\phi^2 + \lambda\phi^4]\, d\mu \,. \tag{0.14}$$

Even in flat space, it is not clear how to give a non-perturbative definition of the theory and its correlation functions, but we can do perturbation theory, i.e. consider a formal power series expansion of the correlation functions in the parameter λ. In curved spacetime, one has to rethink how perturbation theory, especially renormalization, works. Because a curved spacetime does not have any isometries, this is far from obvious, and sophisticated mathematical tools such as "microlocal analysis", and also new concepts were needed for a full solution of this problem [4, 10, 11]. The perturbation series has the general form

$$\langle \phi(X_1)\cdots\phi(X_n)\rangle^C_{0,\lambda} = \sum_{V\geq 0} \sum_{G \text{ with } V+n \text{ vertices}} \lambda^V \,\mathrm{Sym}(G)\, I_G(X_1,\ldots,X_n) \tag{0.15}$$

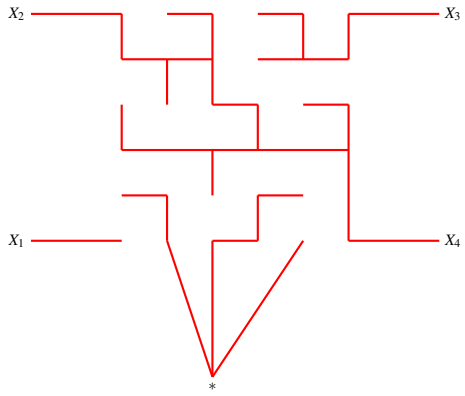
for the connected correlators, where I_G is the contribution from a connected Feynman graph G with V interior vertices and n external legs, weighted by the appropriate symmetry factor (equal to the order of the automorphism group of the graph, $|\mathrm{Aut}(G)|^{-1}$). The following is an example of a graph G with $n = 4$ external lines:



A closed form expression for I_G in deSitter which includes renormalization has recently been given in [12]. The formula is given as a multiple Mellin-Barnes integral generalizing the formula for the free field given above. The integration parameters are in correspondence with the "forests" in a graph G^* associated with G, which is obtained as follows:

- G^* has the same vertices as G, and an additional vertex called "$*$".
- Two vertices $i, j \in \{1, \dots, V+n\}$ in G^* are connected by a single line if these vertices are connected by at least one line in G, and they are not connected otherwise.
- Each of the vertices $i = n+1, \dots, n+V$ is connected to $*$ with a line.

Then, we consider, inside the graph G^* the collection of tree graphs, or more generally, disjoint unions of tree graphs called "forests". There are two families of forests which play a role in our formula for I_G, eq. (0.16): One is $\mathfrak{T}_n$, the set of all forests F with n tress, such that F contains all the vertices of G^*, and such each tree in F contains precisely one or two external points $X_i, i = 1, \dots, n$. A subset of this is the set $\mathfrak{T}_n(i, j)$, which contains exactly one tree connecting point X_i with point X_j. $\mathfrak{T}_{n+1}$ is defined in a similar way. For example, for the above graph G, an associated forest F in $\mathfrak{T}_4(2,4)$ connecting X_2 with X_4 can look like this:



In the formulation of the following theorem, it is useful to introduce a special trivial forest $\Phi \in \mathfrak{T}_{n+1}$ consisting of the trivial trees which are the vertices $X_i, i = 1, \dots, n$ and the tree connecting $*$ with the interaction vertices $n+1, \dots, n+V$. We then have for the perturbations of a principal series scalar field ($c = 3/2 + i\rho$, or $m^2 \geq \frac{9}{4}H^2$):

Theorem 1. The deSitter Feynman integral $I_G(X_1, \dots, X_n)$ is given by

$$\boxed{I_G = K_{c,G} \int_{\vec{w}} \Gamma_G(\vec{w}) \prod_{1 \leq i \neq j \leq n} (1 - Z_{ij})^{\sum_F w_F}} \,, \tag{0.16}$$

where the sum $\sum_F$ in the exponent is over all forests in $\mathfrak{T}_n(i, j)$. $K_{c,G}$ is a numerical constant, and Z_{ij} are the point-pair invariants $H^2 X_i \cdot X_j$. Furthermore, $\Gamma_G(\vec{w})$ is the meromorphic kernel[5]

$$\Gamma_G(\vec{w}) := \frac{\Gamma(\frac{5}{2} + \sum_F w_F) \prod_F \Gamma(-w_F)}{\Gamma(\frac{5}{2} + \sum_{F \in \mathfrak{T}_n} w_F)} \times \tag{0.17}$$
$$\frac{\prod_{(ij) \notin \Phi} \Gamma(\frac{3}{2} + i\rho + \sum_{F \ni (ij)} w_F) \Gamma(\frac{3}{2} - i\rho + \sum_{F \ni (ij)} w_F) \Gamma(1 - \sum_{F \ni (ij)} w_F)}{\prod_{(ij) \in \Phi} \Gamma(\frac{5}{2} + \sum_{F \not\ni (ij)} w_F)}$$

[5] Here we assume for notational simplicity that G is such that each pair of vertices is connected by precisely one line. In [12], the general formula was given which is of exactly the same nature.

All sums/products are over forests F from $\mathfrak{T}_n \cup \mathfrak{T}_{n+1}$, unless otherwise indicated, with the forest Φ always omitted. The integration $\int_{\vec{w}} = \prod_F \int \frac{dw_F}{2\pi i}$ is over suitable [12] paths in $\mathbb{C}$ which are asymptotically parallel imaginary axis, and which avoid the the poles of the kernel Γ_G.

The contour integrals are shown to be absolutely convergent for "Euclidean configurations" X_i. For general configurations, the formula must be understood in the sense of distributions, with a suitable "$i\varepsilon$"-prescription, i.e. as the distributional boundary value of an analytic function [12]. To prove this remarkably elegant formula, one has to make use of a number of techniques, including combinatorial results from graph theory, as well as methods from renormalization theory in curved space [10, 11, 4].

By considering the question how far the integration contours in I_G can be deformed to the left without crossing any poles, one can again derive a decay result for the connected correlation functions. It turns out that we get exactly the *same* result as in the free theory (0.12) for the $n = 2$-point function, and a similar result also holds for the higher n-point functions [6]. Of course, now this does not follow now simply from Wick's theorem, which does not hold in the interacting theory. These estimates would allow one to show that

$$\langle \phi(t,\mathbf{x})\rangle_\Psi = O(\mathrm{e}^{-\frac{3H}{2}t}) \,, \quad \text{as } t \to \infty, \tag{0.18}$$

for states $|\Psi\rangle$ in the interacting theory built as in eq. (0.13), but now upon the Euclidean vacuum $|0,\lambda\rangle$ in the interacting theory whose correlators are (0.15). As in the free theory, this formula can be interpreted as saying that, in essentially any state, the expectation value of $\phi(t,\mathbf{x})$ will tend to zero exponentially in time. It is a version of the "heat death" fate of the universe in the context of an interacting quantum field theory. It follows similarly that the n-point functions of $|\Psi\rangle$ also approach those of $|0,\lambda\rangle$ at an exponential rate in the future, and this says that also at the level of correlations, any memory of the state on its initial condition is rapidly washed out.

Thus, the bottom line of this article is that (i) the "heat death-", or "cosmic no-hair-" scenario appears to be correct within the context of perturbative quantum field theory around a (sufficiently) massive free field in deSitter spacetime. (ii) It means that expectation values of deSitter quantum fields rapidly converge to zero, no matter what was the nature of the initial state, and the higher correlation functions converge to those of a preferred "vacuum like" state. It would be interesting to generalize this result to other field theories, most notable massless ones such as (i) the graviton, (ii) gauge fields, or simply massless scalars.

References

[1] B. Allen: "Vacuum states in deSitter space," Phys. Rev. **D**32, 3136 (1985)

[2] J. Bros, H. Epstein and U. Moschella, "Particle decays and stability on the de Sitter universe," Annales Henri Poincare **11**, 611 (2010); J. Bros, H. Epstein and U. Moschella, "Lifetime of a massive particle in a de Sitter universe," JCAP **0802**, 003 (2008)

[3] J. Bros, H. Epstein and U. Moschella, "Analyticity properties and thermal effects for general quantum field theory on de Sitter space-time," Commun. Math. Phys. **196**, 535 (1998); J. Bros and U. Moschella, "Two-point Functions and Quantum Fields in de Sitter Universe," Rev. Math. Phys. **8**, 327 (1996)

[4] R. Brunetti and K. Fredenhagen, "Microlocal analysis and interacting quantum field theories: Renormalization on physical backgrounds," Commun. Math. Phys. **208**, 623 (2000)

[5] D. Buchholz and J. Schlemmer, "Local Temperature in Curved Spacetime," Class. Quant. Grav. **24**, F25 (2007)

[6] S. M. Carroll, Living Rev. Rel. **4**, 1 (2001).

[7] A. Higuchi and S. S. Kouris: "The covariant graviton propagator in deSitter spacetime," Class. Quant. Grav. **18** 4317 (2001); "On the scalar sector of the covariant graviton two-point function in deSitter spacetime," Class. Quant. Grav. **18** 2933 (2001); A. Higuchi and R. H. Weeks, "The physical graviton two-point function in deSitter spacetime with S^3 spatial sections," Class. Quant. Grav. **20** 3005 (2003);

[8] A. Higuchi: "Tree level vacuum instability in an interacting field theory in deSitter spacetime," arXiv:0809.1255; "Decay of the free-theory vacuum of scalar field theory in deSitter spacetime in the interaction picture," Class. Quant. Grav. **26** 072001 (2009)

[9] S. Hollands, "The operator product expansion for perturbative quantum field theory in curved spacetime," Commun. Math. Phys. **273**, 1 (2007)

[10] S. Hollands and R. M. Wald, "Local Wick polynomials and time ordered products of quantum fields in curved spacetime," Commun. Math. Phys. **223**, 289 (2001)

[11] S. Hollands and R. M. Wald, "Existence of local covariant time ordered products of quantum fields in curved spacetime," Commun. Math. Phys. **231**, 309 (2002)

[6] The same result has been obtained by [13] using a different method.

[12] S. Hollands, "Correlators, Feynman diagrams, and quantum no-hair in deSitter spacetime," [arXiv:1010.5367 [gr-qc]].

[13] D. Marolf and I. A. Morrison, "The IR-stability of deSitter QFT: results at all orders." arXiv:1010.5327 [gr-qc]

[14] E. Mottola, "Particle Creation In De Sitter Space," Phys. Rev. D **31**, 754 (1985); P. Mazur and E. Mottola, "Spontaneous Breaking Of De Sitter Symmetry By Radiative Effects," Nucl. Phys. B **278**, 694 (1986); I. Antoniadis and E. Mottola, "Graviton Fluctuations In De Sitter Space," J. Math. Phys. **32**, 1037 (1991).

[15] V. F. Mukhanov, H. A. Feldman and R. H. Brandenberger, "Theory of cosmological perturbations. Part 1. Classical perturbations. Part 2. Quantum theory of perturbations. Part 3. Extensions," Phys. Rept. **215**, 203 (1992).

[16] A. M. Polyakov: "DeSitter space and eternity," Nucl. Phys. **B797** 199 (2008); "Decay of vacuum energy," arXiv:0912.5503

[17] A. Strohmaier, R. Verch and M. Wollenberg, "Microlocal analysis of quantum fields on curved spacetimes: Analytic wavefront sets and Reeh-Schlieder theorems," J. Math. Phys. **43**, 5514 (2002) [arXiv:math-ph/0202003].

[18] N. C. Tsamis and R. P. Woodard, "Quantum Gravity Slows Inflation," Nucl. Phys. B **474**, 235 (1996); N. C. Tsamis and R. P. Woodard, "The quantum gravitational back-reaction on inflation," Annals Phys. **253**, 1 (1997); "Strong infrared effects in quantum gravity," Annals Phys. **238**, 1 (1995); "The Structure of perturbative quantum gravity on a De Sitter background," Commun. Math. Phys. **162**, 217 (1994); N. C. Tsamis and R. P. Woodard, "Physical Green's functions in quantum gravity," Annals Phys. **215**, 96 (1992).

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Letters in Support of the ESI

edited by W.L. Reiter

The Austrian Ministry of Science informed the ESI officially on November 8, 2010, that the Institute's funding will be terminated with effect from January 1, 2011.

News of the funding cut quickly spread among the scientific community and sparked off a large number of messages to Dr. Beatrix Karl, the Austrian Federal Minister of Science and Research, in support of the ESI.

The remarkable support for the ESI by the international research community was a major contributing factor in discussions between the Austrian Ministry of Science and Research, the University of Vienna and the Erwin Schrödinger Institute, with the aim of allowing the Institute to continue its mission.

Here follows a small selection of messages addressed to Minister Dr. Karl in support of the ESI.

The ESI would like to take this opportunity to express its gratitude to the scientific community for the overwhelming support of the ESI during these interesting times.

A list of physicists and mathematicians who sent messages to Dr. Karl is at http://www.mat.univie.ac.at/~kschmidt/ESI-Webseite.html.

Jean-Michel Bismut
Robbert Dijkgraaf
Peter Goddard
Felix Otto
Scott Sheffield

Dear Dr Karl,

We have learnt with great distress of the intention of the Austrian Government abruptly to cease funding for the Erwin Schroedinger Institute in Vienna.

Together we constituted the international review committee for the Institute commissioned by the then Federal Minister of Science and Research, Dr Johannes Hahn, that reported in June 2008.

We found that, incontrovertibly, the Erwin Schroedinger Institute is one of the world's leading research institutes in mathematics and theoretical physics, with an efficiency in terms of cost that is unequalled anywhere else in the world, and that it has a great impact on the standing of Austria in these areas of research, in particular in attracting leading mathematical scientists to positions in Austria. [Our report is attached.]

The loss of, or damage to, the Institute would be a disaster internationally for research in the mathematical sciences and would undo the great benefit that Austria has derived at comparatively little cost from the work of the Institute.

Yours sincerely

Jean-Michel Bismut, Member of the Académie des Sciences (Paris)

Robbert Dijkgraaf, President, Royal Netherlands Academy of Arts and Sciences

Peter Goddard, Director, Institute for Advanced Study, Princeton, NJ, USA

Felix Otto, Director, Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

Scott Sheffield, Courant Institute, New York University, NY, USA

November 9, 2010

CERN Theory Group

Mit Erstaunen und Bestürzung hat die CERN Theoriegruppe die Nachricht aufgenommen, daß das Bundesministerium für Wissenschaft und Forschung dem Erwin-Schrödinger Institut Wien (ESI) kurzfristig zum 1. Januar 2011 die Finanzierung gestrichen hat. Das Erwin-Schrödinger-Institut ist eine international etablierte, wissenschaftliche Einrichtung, die zur weltweiten Sichtbarkeit und zum internationalen Austausch der österreichischen Forschung herausragende Beiträge leistet. Angesichts der großen wissenschaftlichen Bedeutung und internationale Anerkennung, die das Erwin-Schroödinger-Institut aufgrund seiner engagierten Förderung des interdisziplinären wissenschaftlichen Austausches auf dem Gebiet der Mathematik und ihrer Anwendungen in den Naturwissenschaften genießt, bittet die CERN Theoriegruppe das Ministerium dringend, seine Entscheidung über die Einstellung der Finanzierung des ESI zu überprüfen und zu revidieren.

Urs Achim Wiedemann
in the name of CERN Theory Group

Luis Alvarez-Gaume, Ignatios Antoniadis, Georgi Dvali, John Ellis, Gian Giudice, Wolfgang Lerche, Martin Luescher, Michelangelo Mangano, Urs Achim Wiedemann, Guido Altarelli, Alvaro de Rujula, Torleif Ericson, Sergio Ferrara, Andre Martin, Gabriele Veneziano Stefano Frixion, Christophe Grojean, Neil Lambert, Julien Lesgourgues, Antonio Riotto, Gavin Salam, Stefan Schaefer, Geraldine Servant, Peter Skands, Johannes Walcher, James Wells

November 15, 2010

Goulnara Arzhantseva
Adrian Constantin
Ludmil Katzarkov
Christian Krattenthaler
Walter Schachermayer

Dear Chancellor Mr. Faymann, dear Vice-Chancellor Mr. Pröll, dear Minister Mrs. Karl,

We are speech-less!

We are speech-less in view of what you are about to perpetrate.

You are about to extinguish in a stroke, what one of the governments preceding yours (Chancellor Vranitzky, Vice-Chancellor and Minister Busek) created in 1993: the Erwin Schroedinger Institut for Mathematical Physics.

Since its foundation, this institute developed into an international top institute, standing in a row with famous research institutes such as, for example, the Mathematical Sciences Research Institute in Berkeley, the Isaac Newton Institute in Cambridge, the Institut Henri Poincaré in Paris, the Max Planck Institut in Bonn

or the Mathematical Research Institute Oberwolfach. Where ever we meet prominent colleagues abroad, at some point there is always talk of the Erwin Schroedinger Institut, and then these colleagues report in glowing terms of this institution, full of praise for the stimulating atmosphere and for the outstanding quality of the scientific programmes at the institute. The Erwin Schroedinger Institut is international meeting point of the leading scientists in Physics and Mathematics who, together with the local top researchers and students, exchange their ideas here in an intense scientific dialogue. In that way, they do not only interact between themselves, but at the same time they trigger enormously important impulses for the local research groups.

All this shall be history now. "No, no, the Erwin Schroedinger Institut does not have to close for good, it is supposed to seek shelter under a bigger institution - the University of Vienna." We beg your pardon, we can only take this hint as sheer cynicism: this is the classic case of a child abandonment, where the "child" is given to an institution that itself does not know how to finance its *actual* tasks.

The damage that you are about to cause is enormous. It is trivial to destroy something that has grown continuously over 17 years in a stroke. However, 20 years will not suffice to make up this damage. Many of the outstanding international recruitments of new professors in the fields of Physics/Mathematics have been possible only in view of the perspectives that the Erwin Schroedinger Institut offers as an international place of interchange of ideas. (Three of the signers do not hide that this has been a crucial argument for accepting the offer from Vienna.) Now this "attraction" will not exist anymore, which will make it enormously more difficult for international top recruitments in Physics/Mathematics (which - as should be well-known - belong to the few internationally acknowledged top disciplines in Austria). Moreover, you should not underestimate the mobility of top scientists engaged in Austria at the moment.

That you "do not even ignore" the recommendations of the four international top physicists and mathematicians who evaluated the Erwin Schroedinger Institut under the commission of the Austrian Ministry of Science and Research, and who confirmed - so-to-say "officially" - the top rank of the Institute, does not surprise us, given the context. You will be able to imagine what these four think about all this. We ask you to look at these official documents and read them carefully, before you pursue to withdraw the funds of this world famous research institution.

To express it in one sentence: everything else than the immediate withdrawal of your decision concerning the (non-)future of the Erwin Schroedinger Institut would be a shame for Austria, and it would cause enormous damage for the scientific landscape in Austria, irreparable for a very long time.

Sincerely yours,
Goulnara Arzhantseva (ERC Starting Grant 2010)
Adrian Constantin (ERC Advanced Grant 2010)
Ludmil Katzarkov (ERC Advanced Grant 2008)
Christian Krattenthaler (Wittgensteinpreis 2007)
Walter Schachermayer (Wittgensteinpreis 1998, ERC Advanced Grant 2009)
3. November 2010

Alain Connes

Dear Dr. Beatrix Karl,

I was in the original scientific committee that founded in 1993 the Schrodinger Institute which has since then been a remarkable success for the research in Physics and Mathematics at the International highest level. I write to give my strongest support in the hope that the decision to terminate the funding by the Austrian Ministry of Science with effect from January 1, 2011, can be reversed. It would be a catastrophy to do that and would be an irreversible loss for the science in Austria and its International reputation. Marvels like that are easy to destroy and very difficult to restore.

With best regards
Alain Connes
Professor of Mathematics at College de France, Paris
Fields Medal 1982
November 9, 2010

Pavel Exner

Esteemed Madam Minister,

I have been informed that government of your country intends to perform 'radical structural change in the consolidation of Austrian extrauniversity research'. With a great uneasiness I learned that this measure, when translated into practical terms, would mean in particular termination of the Erwin Schrödinger Institute in Vienna.

With all due respect I have to say that I regard such a move unfortunate and unwise, and not only because it will eliminate an activity associated with the name of one of the greatest Austrian scientists.

The scientific community welcomed the fact that political leadership of Europe recognized in recent years the fact that support of scientific excellence is the only way in which our continent can avoid losing in the ever intensifying global competition, and started acting accordingly. In this situation closing down a centre which is renowned as a breeding ground of would seriously harm not only your country but also the the whole European community of mathematicians and mathematical physicists.

(...)

I believe, Esteemed Madam Minister, that the Austrian government will be able to reconsider the decision in the interests of your country, Europe, and excellent science the continent needs. With best regards, Sincerely yours
Pavel Exner
IAMP President
November 9, 2010

Della Fenster

There are precious few math institutes in the world and only one located in a vibrant city, the Erwin Schroedinger Institute (ESI). Far more importantly, there are precious few math institutes that have made a deliberate effort to encourage more women in mathematics. Let me clarify that point. Many math institutes and, in general, many universities, have adopted popular rhetoric that sug-

gests support for women in mathematics and science. In practice, however, very few scientific institutes and universities actually take proactive steps to move that thought from an idea to reality. The ESI is one mathematics institute that has overtly encouraged women and young scholars in their mathematical pursuits. As a case in point, the ESI was willing to take on the extra effort involved in bringing this mother of three to the ESI for my six-month sabbatical in 2005 in order for me to pursue a collaborative project with a colleague at the University of Vienna. The ESI Directors and Administrative Staff helped with the myriad of documents and the arrangements for schools and affordable housing. It takes this kind of extra effort for a woman to consider an extended stay at a mathematics institute. That investment on the part of the ESI has led to three publications, a book project, and three conferences organized by this collaborative team. Publications and conferences are the typical standards we use to measure success in mathematics. The ESI provided much more than this type of measurable output, however, since those initiatives not only indicated their support for women in mathematics but also made it a reality in the form of welcoming women and young scholars to conferences that resulted from this collaborative research. I write to ask you to reconsider your decision to terminate funding of the Erwin Schroedinger Institute. While advancements in the field form the critical contribution the ESI makes to mathematics (and physics), their efforts not only to include but also encourage women in the field stand as a very close second to their primary aim. The ESI does both with success. Thank you for your consideration of this request.

Della Fenster
Professor of Mathematics
University of Richmond
November 1, 2010

Jürg Fröhlich

Sehr geehrte Frau Minister,

meine Kolleginnen und Kollegen aus Wien haben mich eben von der gänzlich unerwarteten Entscheidung der Österreichischen Bundesregierung in Kenntnis gesetzt, die Finanzierung des weltbekannten "Erwin Schrödinger Instituts" (ESI) auf den Anfang des kommenden Jahres zu beenden. Es ist zu befürchten, dass dieses Institut deshalb seine Tätigkeit wird einstellen muessen, und längst geplante Besucher- und Forschnugsprojekte aufgegeben werden müssen. Daraus wird den Grundlagenwissenschaften in Österreich und in ganz Zentraleuropa ein erheblicher Verlust an Internationalität und Prestige erwachsen - mit möglicherweise verheerenden Folgen für den wissenschaftlichen Nachwuchs.

Unsere Kollegen und Kolleginnen in Wien haben es fertig gebracht, in mühevoller Arbeit ein weltbekanntes Programm-Institut in den Bereichen Mathematik und theoretische Physik aufzubauen. Ich finde die Neuigkeit, dass dieses Institut nun seine überaus erfolgreiche Tätigkeit im Dienste der Grundlagenforschung einstellen soll, bestürzend. Mit politischen Entscheidungen dieser Art wird die Motivation der jungen Generation, ihr Leben einer wissenschaftlichen Tätigkeit zu widmen, untergraben. Die älteren Kolleginnen und Kollegen, die Verantwortung für einen lebendigen internationalen wissenschaftlichen Austausch in Wien übernommen haben und diese mit grossem Erfolg wahrgenommen haben, werden sich in Zukunft kaum noch fuer solche Aufgaben gewinnen lassen, wenn sie befürchten müssen, nach Jahren der Anstrengung vor einem Scherbenhaufen zu stehen. Das ESI ist für die Mathematik und theoretische Physik in Österreich ein Fenster zur Welt. Wird es geschlossen, so zieht wieder mehr wissenschaftliche Provinzialität in Österreich ein - trotz Internet!

Erfolgreiche wissenschaftliche Tätigkeit und fruchtbarer Austausch unter Wissenschaftlerinnen und Wissenschaftlern laufen in längeren Zeiträumen von mehreren Jahren bis Jahrzehnten ab. Ihnen den Rythmus von Wiederwahlperioden politischer Verantwortungsträgerinnen und -trägern und/oder die Perioden von Wirtschaftszyklen aufzuzwingen, ist katastrophal und führt letztlich in die Erfolglosigkeit.

Der gegenwärtige Trend, die Finanzierung der Wissenschaft mehr und mehr kompetitiv und in kurzen Zeiträumen zu organisieren und damit den Druck auf die in der Wissenschaft Tätigen mehr und mehr zu erhöhen, nur noch kurzfristig machbare Projekte anzugehen - und vorallem solche, die zu einer Modeströmung gehören - wird in absehbarer Zukunft ziemlich katastrophale Folgen zeitigen. Da sowohl die Mathematik als auch die Physik zu den Grundpfeilern unserer wissenschafts- und technikgeprägten Welt gehören, werden negative Folgen auch in der technischen Innovationskraft Ihres (und meines) Landes und seiner Wirtschaft zu beobachten sein.

Wirklich erfolgreiche und originelle Grundlagenforschung ist nur auf der Basis verlässlicher und voraussehbarer Finanzierung möglich. Die Grundlagenforschung ist der Sauerstoff der angewandten Forschung. Verkümmert die Grundlagenforschung, so werden auch die angewandte Forschung und Technik leiden.

Wir alle verstehen, dass die vergangenen Jahre schwierig waren und die Regierenden zu neuen Planungen und insbesondere zu Sparmassnahmen zwingen. Mit vernünftigen Sparmassnahmen können wir Wissenschaftsleute auch umgehen! Aber schon Joseph hat die Versorgung Ägyptens mit Nahrungsmitteln in Zeiträumen von sieben Jahren geplant, obwohl ihm noch keine erfahrenen Ökonomen und Planer zur Seite standen. Er hat in sieben fetten Jahren Vorräte angelegt, die dann auch für sieben magere Jahre ausreichten. Sie werden auch im Sparen nur echten und langfristigen Erfolg haben, wenn Sie einigermassen langfristig planen und über Ihre Regierungszeit hinausdenken.

Lassen Sie mich mit meinen Ausführungen zum Schluss kommen, indem ich in aller Bescheidenheit daran erinnere, dass es auch in der Politik noch Anstand geben sollte! Meine Kolleginnen und Kollegen damit zu desavouieren, dass Sie ihnen ganz kurzfristig die Finanzierung für längst geplante Programme entziehen und sie dazu zwingen, schon zur Teilnahme an solchen Programmen eingeladene Kolleginnen und Kollegen aus aller Welt wieder auszuladen, halte ich schlicht und einfach für unanständig. (Ausserdem ist es völlig demotivierend!) Wenn Sie zum Schluss gelangen, dass es sich Österreich nicht mehr leisten kann, das "Erwin Schrödinger Institut" zu finanzieren, oder wenn Sie der Ansicht sind, die in dieses Institut gesteckten Mittel seien schlecht investiert, dann bitte ich Sie höflich, die Finanzierung nicht plötzlich auszutrocknen, sondern über einen Zeitraum von drei bis fünf Jahren hinunterzufahren! Dann wäre ein geordneter Rück-

zug aus den Aktivitäten des "Erwin Schrödinger Instituts" nämlich möglich. Das gegenwärtige Vorhaben Ihrer Regierung erzeugt dagegen Chaos und Frustration! (In drei bis fünf Jahren sieht die Welt dann möglicherweise ohnehin wieder anders aus.)
Verzeihen Sie mir meine Offenheit und Direktheit! Ich schreibe Ihnen aus Sorge und hoffe, Sie schenken meinen Argumenten wenigstens ein bisschen Beachtung. (Ich darf anfügen, dass ich in der Gründungszeit des ESI Mitglied des wissenschaftlichen Beirats war.)
Hochachtungsvoll,
Prof. Dr. Dr. hc Jürg Fröhlich
Professor für theoretische Physik
ETH Zürich
November 9, 2010

Gian Michele Graf

Sehr verehrte Frau Bundesministerin,
ich habe vor wenigen Tagen mit grosser Überraschung erfahren, dass Ihr Bundesministerium beabsichtigt, die Finanzierung des Erwin-Schrödinger-Instituts für Mathematische Physik (ESI) ohne geeigneten Ersatz zu streichen.
Ich brauche Sie wohl kaum vom internationalen Ruf des Schrödinger-Instituts zu überzeugen, da Sie einerseits diesen selbst öffentlich hervorgehoben haben, so etwa in einer Pressemitteilung vom 27. Juli dieses Jahres, und Ihnen andererseits die Evaluationsgutachten hochranginger Gutachter bekannt sind.
Es geht mir hier mehr um zwei andere Aspekte. Der erste ist die Entgegnung einer potenziellen Kritik, die aus Erfahrung oft bei Sparmassnahmen zulasten von exzellenten Institutionen mit internationaler Ausstrahlung hervorgebracht wird, und zwar die Frage nach dem Nutzen für das Land, welches die Institution trägt.
Dazu ist zu sagen, dass Österreich eine Tradition in Mathematischer Physik auf höchsten Niveau aufweist, auf die es stolz sein sollte. Auf dem Gebiet, das durch Schrödinger begründet wurde (und das zufälligerweise auch meines ist) haben Leute wie Walter Thirring (Gründer des ESI) und Jakob Yngvason (heutiger Direktor des ESI) und Andere Erkenntnisse zutage gebracht, die weit über die mathematische Physik hinaus – von der Teilchenphysik bis hin zur Physik der kondensierten Materie – nicht mehr wegzudenken sind. Da Sie die vom ESI getragene Nachwuchsförderung besonders schätzen, erlauben Sie mir zu erwähnen, dass Ihr Land auch auf aussergewöhnliche junge Forscher in Mathematischer Physik zählen kann, so etwa auf Robert Seiringer. Dies bloss um zu bekräftigen, dass die wissenschaftlichen Erfolge, die das ESI heute beleben, auch in Zukunft nicht ausbleiben werden, wenn ihm die Mittel dazu erhalten bleiben werden.
Der zweite Aspekt ist, dass das ESI in seiner Form der Schaffung und des Austausches von wissenschaftlicher Erkenntnis ein Erfolgsmodell darstellt. Es war zur Zeit seiner Gründung im Jahr 1993 eines der allerersten seiner Art und wurde seither oft kopiert, zuletzt 2010 in Rom mit Unterstützung des italienischen Staatspräsidenten. Es wäre seltsam und bitter, wenn die Kopien gedeihen würden, das Original aber verschwinden sollte.
Es würde mich freuen, wenn Sie diese Gedanken in Ihre Entscheidung zur Zukunft des ESI einbeziehen könnten.
Mit freundlichen Grüssen,
Gian Michele Graf
Professor für Theoretische Physik
ETH Zürich
November 9, 2010

Mikhail Gromov

Dear Dr. Beatrix Karl,
I have just learned from my colleagues in Vienna, that the funding of the Erwin Schroedinger Institute is planned to be terminated.
The Erwin Schrödinger Institute is the most prestigious of Austrian Institutions in mathematics which has built its high reputation and promoted the international image of the Austrian science in the course of the last two decades.
Nothing comparable to this can be reconstructed in an appreciable stretch of time.
Closing Erwin Schrödinger Institute will be a sad event not only for Austrian science, but for all mathematicians and theoretical physists around the world.
I think, I express the opinion of the whole international mathematical community by asking you to reconsider this decision.
Sincerely
Mikhail Gromov,
Professor
Institut des Hautes Études Scientifiques,
France.
November 1, 2010

Arthur Jaffe

Dear Minister Karl,
It is with great dismay that I learn of the potential decision by the Austrian Government to discontinue the research funding for the Erwin Schroedinger Institute. From an international perspective, this is a total disaster. As an independent institution, the ESI has served as a beacon: it elevated Vienna to a modern vortex of activity in mathematics and physics. It has served as a place from which exciting ideas have evolved. And it has become a central focus for joining leading researchers from the East and from the West.
The future of theoretical science and its long-term impact depends on the success of small, relatively inexpensive, but enormously important institutions like ESI. In China several new independent mathematical institutes of this sort are now being constructed. That government there regards ideas from science as the key to future success, and mathematics and theoretical physics play a central role in that plan.
It is simpler, as well as much less expensive, to preserve a successful institution than to create a new tradition. So I encourage the Austrian government to reconsider this particular decision.
Sincerely yours,
Arthur Jaffe
Landon T. Clay Professor of Mathematics and Theoretical Science, Harvard University
Past President American Mathematical Society, and Past Chair Council of Scientific Society Presidents
November 9, 2010

Sir Vaughan F. R. Jones

Dear Dr. Beatrix Karl,

It was with utter dismay that I just learned of the decision to cease funding for the Erwin Schrodinger Institute!!!

I have been a regular visitor at the institute for almost 15 years and I was a member of the scientific advisory board for several years. I was just about to plan my next visit. The Schrodinger institute is a major centre of international research in mathematical physics and should be a source of great pride to Austria. Besides which it brings a constant flow of the world's best mathematicians and physicists to Vienna. I can understand that the current economic climate is forcing difficult decisions to be made but a place like the Schrodinger institute is an investment for the future and to eliminate such institutes makes recovery doubly difficult. ESI has taken a long time to build up and establish its reputation as a world-leading institute. This involved the dedication and hard work of many people over a long period of time. For it to be torn down in a matter of a couple of months is a waste of stunning proportions.

I urge you to do all in your power to reverse this decision and reinstate funding for ESI.

Sincerely,

Sir Vaughan F. R. Jones

FRS, NAS, KNZM,

Fields Medal 1990.

November 9, 2010

A. A. Kirillov

Herr Minister,

The Erwin Schroedinger Institute is a world-known center of Physics and Mathematics, may be, the most known scientific organization in Austria. The first class faculty, the excellent conditions for visitors and conferences, the multitude of publications put it to the same level as MSRI in Berkeley, USA, Max Plack Institute in Bonn, Germany, the Newton Institute in Cambridge, UK, IHES in Bures-sur-Yvette, France.

The termination of activity of ESI will be a great loss for the Mathematics and Physics and very harmful for the reputation of Austria as a liberal and enlightened state.

A.A.Kirillov

Professor of Mathematical Department of the University of Pennsylvania.

Francis J. Carey Professor

November 9, 2010

Maxim Kontsevich

Dear Dr. Karl,

I've learned recently about plans of Austrian government to terminate the funding of Erwin Schroedinger Institute in Vienna with effect from January 1, 2011. I think it is a very unwise and deplorable decision.

I know very well the institute, and visited it many times after its creation in 1993.

The Institute is the major meeting point in Europe for mathematical physics, and was a place of a great variety of very fruitful meetings and exchanges in the scientific community.

There is no other Institute in Europe which could replace ESI unique role.

I hope that the Ministry of Science will change its decision and continue the funding.

Yours sincerely,

Maxim Kontsevich,

Professor of Mathematics at the Institute des Hautes Etudes Scientifiques, Bures-sur-Yvette, France

Fields Medal 1998,

Crawford Prize 2008.

November 17, 2010

Stephen S. Kudla

Dear Dr. Karl,

I recently heard that a decision has been reached to eliminate the ESI in Vienna at the end of this year. This move would certainly be a disaster for advance mathematics and physics in Austria.

Over the past years, the mathematical activities at the ESI have greatly raised the international profile of Austria and the ESI is on its way to establishing itself as one of the world's premier research centers along with the IHP in Paris, the Fields Institute in Toronto, and MSRI in Berkeley.

Such institutions are essential to progress in mathematical research and their development is a long term process. The advances that have been made in the growth of the ESI can be destroyed, it seems, with the stroke of a pen, but, once destroyed, they will not be easily recovered. Mathematics research is not like road construction, where labor laid off to save money in tight times can be hired again and set to work at a moment's notice.

Finally, the presence of the ESI vibrant research environment and, in particular, the large number of outstanding visitors from around the world has a significant impact on the mathematical life in Vienna and especially on the development of young Austrian mathematicians. I do not know the budget numbers, but I imagine that the money saved by eliminating the ESI will be negligible, whereas the damage to Austria's presence in mathematical research caused by this step will be extensive and irreparable.

Sincerely,

Stephen S. Kudla

Professor of Mathematics and Canada Research Chair,

University of Toronto

November 9, 2010

Joel Lebowitz

Dear Dr. Karl,

I was absolutely shcked to learn that the Austrian government is withdrawing its support from the ESI, effectively closing what has been an outstanding institute.

Surely this is not in the interest of science and in particular of Austrian science of which this institute is an important part.

I very much that you are able to reverse this decision. Sincerely yours,

Joel Lebowitz

Center for Mathematical Sciences Research Rutgers,
The State University of New Jersey
November 1, 2010

Elliott Lieb

Dr. Beatrix Karl
Federal Minister of Science and Research
Dear Minister Karl,

I write about the almost incredible news that the Erwin Schroedinger Institute will no longer be funded by the Austrian government. It is almost impossible to believe that one of the most successful, cost-effective scientific enterprise is to be terminated. The value of ESI, in terms of scientific output, in terms of value to young researchers and in terms of international recognition has been well documented by the report of the Goddard Commission and by the many letters you have received asking for a reversal of this unfortunate decision.

Normally, one might say that internal funding decisions by the Austrian government are not my business. But in this case it is. Many people contributed to building up ESI, and I was one of those who participated by spending 13 years on the scientific board of ESI. It is a personal loss to know that that effort eventually led to nothing permanent.

Please consider the effect that your decision will have on the younger generation of Austrian scientists. Do you really want to convey the message, as you surely will, that devotion to the scientific infrastructure of Austria is a waste of time? It is not easy to build up internationally recognized scientific enterprises, and I urge you to reverse this decision.

Yours sincerely,
Elliott Lieb
Professor of Mathematics and Physics,
Princeton University.
Member of the Österreichische Akademie der Wissenschaften
Österreichisches Ehrenzeichen für Wissenschaft und Kunst (2002)
November 9, 2010

Elon Lindenstrauss

Dear Dr. Beatrix Karl,

This letter is to express my strong support for the Schrodinger Institute and its mission, and my astonishment that the funding of such a wonderful and cost effective scientific institute is in jeopardy.

The Schrodinger Institute has established itself, with the Mathematisches Forschungsinstitut Oberwolfach, the Newton Institute in Cambridge, the Institute for Advanced Study in Princeton and MSRI in Berkeley as one of the leading mathematical research institutes worldwide.

I believe it is a unique and valuable resource to the Austrian mathematical community: a window through which the most exciting current developments in mathematics are brought to Vienna for the benefit of Austrian mathematicians at all stages of their career. As an Israeli mathematician (my complete curriculum vitae is attached), I wish Israel had a mathematical research institute of comparable standing. Should the Schrodinger Institute be closed or significantly scaled down, the worldwide mathematical community will lose a well-loved and efficiently managed research venue, but this void will likely be filled elsewhere in the world Ñ perhaps in Poland who is trying to build a research institute, perhaps in China with its unlimited resources.

The damage to Austrian mathematics, and by extension Austrian science, however, will be irreversible.

I appreciate that these are complicated times economically. I am not sure exactly how large the budgets of ESI is (or more precisely - and unfortunately - was). I believe that the benefits Austria receives from this institute outweigh this relatively small but significant funding by a very large factor. I have friends in the high-tech industry in Israel, including quite senior people in some of the largest companies active in the sector. I know from firsthand knowledge that Israel's wellrecognized excellence in mathematics was a significant factor in the blossoming of this multibillion-dollar industry in Israel.

I would also like to stress that reestablishing a center such as the Schrodinger Institute is not something that can be done with 10 or even 50 million Euros: it requires world recognized mathematicians of high scientific stature and simultaneously possessing first-rate organizational skills to devote a significant portion of their cherished research time to the goal of building an institute. Excellent mathematicians with organizational skills are a very rare commodity (Austria is quite lucky to have a few, such as the current director Prof. Klaus Schmidt).

Should the ESI be significantly scaled down or closed I doubt if such people can be found to resurrect the Institute. Running an institute such as ESI also requires the credibility and goodwill to convince prominent mathematicians from around the world to participate in organizing programs (I myself am somewhat involved in a program on ergodic theory and number theory that was supposed to take place next autumn, and intended to come for a significant period of time to this program. This program, clearly, would be hurt by this uncertainty).

Mathematics is an abstract subject (though less abstract than is commonly perceived). It is remarkable that it is useful, but its usefulness has been established again and again in surprising ways repeatedly throughout history, especially and spectacularly in recent years with the information revolution.

I think the window to the world ESI serves for the Austrian mathematics community is very important for the academic level of this community. ESI has been widely acknowledged both by mathematicians and by your department as an efficient and effective organization. The uncertainty regarding ESI's future and its funding has already caused damage. Continuation of this uncertainty (or worse) will cause damage for many years to come.

I urge you to support this spectacularly successful and important institute.

Sincerely
Elon Lindenstrauss
Fields Medal 2010
December 3, 2010

MPI Bonn

Sehr geehrte Frau Bundesministerin,

Mit grossem Bedauern und Unverständnis haben wir von Ihrer Ankündigung erfahren, dass Sie die Förderung des Erwin-Schrödinger-Institut durch Ihr Ministerium in Zukunft einstellen wollen.
Bei dem Erwin-Schrödinger-Institut handelt es sich um eine der weltweit führenden Forschungseinrichtungen für Mathematik und Physik. Durch seine herausragende Arbeit hat sich das Erwin-Schrödinger-Institut in in der internationalen Forschergemeinde höchstes Ansehen erworben. Das Erwin-Schrödinger-Institut ist für viele Mathematiker und Physiker in der ganzen Welt die herausragende Institution im Bereich Mathematik/Physik in der österreichischen Wissenschaftslandschaft und es führt viele internationale Besucher nach Wien.
Die Ankündigung passt auch schlecht zu den erfreulichen Plänen für Exzellenzzentren in Österreich. Diese schafft man nicht durch die Schliessung schon vorhandener exzellenter Institutionen sondern eher durch Weiterentwicklung derselben.
Wir bitten Sie daher, Ihre Pläne nochmals zu überdenken.
Wenn Sie bei Ihrer Entscheidung bleiben, dann fügen Sie der Wissenschaft in Österreich einen grossen Schaden zu. Dann werden wichtige Kontaktquellen zwischen der Mathematik/Physik in Österreich und Deutschland, Europa und letztlich der ganzen Welt versiegen. Damit schaden Sie dann letztendlich auch der Entwicklung der Wissenschaft in Europa.
Mit freundlichen Grüßen,
Die Direktoren des Max-Planck-Instituts für Mathematik
November 10, 2010

Andrei Okounkov
Dear Dr. Karl,
I urge you to reconsider your decision to withdraw support from the Erwin Schroedinger Institute.
It is easy to destroy and very difficult to build. Terminating ESI will essentially disconnect the country of Boltzmann and Schroedinger from the international mathematical physics community.
Please think about the role of mathematics and physics in our modern society before ESI is lost.
Sincerely,
Andrei Okounkov
Fields Medal 2006
November 9, 2010

Helmut Rauch
Sehr geehrte Frau Bundesministerin Dr. Karl!
Ich wurde vom Erwin Schrödinger Institut informiert, dass dessen Finanzierung 2011 eingestellt werden soll. Das ist eine der bedrückendsten Informationen, die ich in den letzten Jahren erhalten habe, zumal es sich um eine äußerst erfolgreiche Institution handelt, die sowohl im Inland, aber speziell im Ausland einen positiven Widerhall in Bezug auf die wissenschaftliche Forschung in Österreich hervorgerufen hat.
Zahlreiche Forscher aus vielen Ländern konnten an diesem Institut ihre Arbeit perfektionieren und damit auch die Forschungslandschaft in Österreich bereichern.
Das Gebiet der mathematischen Physik, welches von Professor Walter Thirring weitgehend gestaltet wurde hat eine hohe Attraktivität und weltweite Anerkennung gefunden und kann als Glanzlicht österreichischer Forschung angesehen werden. Die entsprechenden Benchte der Evaluierungskomitees unterstützen diese Aussage.
Als früherer Präsident des FWF, als Mitglied der Österreichischen Akademie der Wissenschaften, aber speziell als Wissenschafter, der auch indirekt von der Tätigkeit des Erwin Schrödinger Instituts profitiert hat, ersuche ich Sie, sehr verehrte Frau Bundesministerin, diese Entscheidung nochmals zu überdenken, da mit einer Schließung der Wissenschaft in Österreich ein nichtreparabler Schaden zugefügt würde.
Mit vorzüglicher Hochachtung, Ihr
Helmut Rauch
November 9, 2010

Gerald Teschl
Sehr geehrte Frau Bundesministerin!
So wie viele andere habe auch ich mit großer Bestürzung die Nachricht über die drohende Schließung des Erwin-Schrödinger-Institut (ESI) ab Jänner 2011 erfahren.
Die Bedeutung des ESI fuer die Wissenschaft in Österreich ist Ihnen ja seit Ihrem letzten Besuch am ESI bekannt und ich werde daher auch nicht näher darauf eingehen.
Ich möchte Ihnen aber ganz kurz schildern was für Auswirkungen ein solcher Schritt hat:
Bei der Verleihung der letzten ERC-Grants haben Sie die österreichischen Forscherinnen und Forscher aufgefordert verstärkt Drittmittel von der EU einzuwerben. Ich habe diesen Aufruf ernst genommen und von der ESF einen Grant zur Abhaltung einer ESF Research Conference am ESI in Wien erhalten. Es handelt sich dabei um eine hoch angesehene Konferenzserie, die wichtige Impulse und internationales Ansehen für den Wissenschaftsstandort Österreich bringen hätte können.
Da zum derzeitigen Stand das ESI wohl nicht mehr in der Lage ist diese Konferenz zu unterstützen, wird die Abhaltung nicht mehr möglich sein. Die Tatsache, dass damit die von der ESF zugesagten Geldmittel in Brüssel bleiben, ist dabei die kleinste Auswirkung. Das viel größere Problem ist, dass sich Österreich damit selbst ins Abseits stellt und der Imageschaden für die Zukunft immens ist.
Abgesehen von der Konferenz wurde ich auch von Kollegen kontaktiert die im kommenden Jahr an einem Programm am ESI teilnehmen wollten und den Aufenthalt auch zu einer Kooperation mit meiner Arbeitsgruppe nutzen wollten. Auch hier ist sowohl der Immageverlust als auch der Schaden für den Wissenschaftsstandort Wien unübersehbar.
Vielleicht ist Ihnen das nicht so bewusst, aber das hervorragende Abschneiden der österreichischen Mathematik beim letzten CHE Excellence Ranking ist wohl in erster Linie auf den unermüdlichen Einsatz der österreichischen Mathematikerinnen und Mathematikern TROTZ der oft widrigen Rahmenbedingungen zurückzuführen. Die derzeitigen Kürzungen im Wissenschaftsbereich verstärken die ohnehin bereits große Frustration unter den WissenschaftlerInnen und setzen mittelfristig nur eine Ab-

wärtsspirale in Gang an deren Ende sicherlich nicht die von der Politik immer wieder geforderte Exzellenz stehen wird.
Hochachtungsvoll,
Gerald Teschl
Fakultät für Mathematik
Universität Wien
November 9, 2010

Robert Tichy

Sehr geehrte Frau Bundesministerin,
soeben habe ich erfahren, dass mit Beginn nächsten Jahres die Finanzierung des Erwin Schrödinger-Instituts in Wien (ESI) seitens des Bundesministeriums für Wissenschaft und Forschung eingestellt werden soll.
Das halte ich aus gesamtösterreichischer wissenschaftspolitischer Sicht für ein Signal in die völlig falsche Richtung und für äußerst kontraproduktiv.
Das ESI stellt einen international weithin sichtbaren Leuchtturm der österreichischen Wissenschaft auf dem Gebiet der Mathematik und der Mathematischen Physik dar.
Hier möchte ich nur darauf hinweisen, dass Mathematik und Physik jene Wissenschaften in Österreich sind, die im Vergleich zu ihrer Größe die mit Abstand besten Evaluierungen aufzuweisen haben, etwa bei der Vergabe von FWF-Projekten, bei START- und Wittgenstein-Preisen.
Das ESI stellt ein unverzichtbares 'Kontaktzentrum' dar, bei dem österreichische ForscherInnen mit weltweit führenden KollegInnen zusammenarbeiten können. Gerade für unsere jungen WissenschaftlerInnen ist diese Möglichkeit der Kooperation unverzichtbar um mit dem höchsten internationalen Niveau Schritt halten zu können. Gerade als Angehöriger einer nicht in Wien ansässigen Universität und bis vor Kurzem Dekan für Mathematik und Physik (und für das NAWI Graz-Projekt mitverantwortlich), möchte ich darauf hinweisen, dass es insbesonders die unabhängige Position des ESI auch ermöglicht hat, alle österreichischen Universitäten in Projekte am ESI einzubinden. Diese Möglichkeit sollte jedenfalls auch für die Zukunft erhalten bleiben.
Ich weiß, dass es in diesen Zeiten nicht leicht ist, die Anliegen der Wissenschaften und der Forschung zu vertreten. Eine Schließung des ESI wäre für das internationale Ansehen Österreichs als Wissenschaftsstandort und für den österreichischen wissenschaftlichen Nachwuchs derart nachteilig, dass ich Sie ersuche, diese Entscheidung nochmals zu überdenken.
Auch ein bloßes Eingliedern in die Universität Wien halte ich aus gesamtösterreichischer Perspektive für nicht optimal.
Mit dem Ausdruck vorzüglicher Hochachtung
Robert Tichy
Technische Universität Graz
Erzherzog-Johann-Universität
November 9, 2010

Anatoly Vershik

Dear Professor Beatrix Karl,
It was a great surprise to recognize about the decision to stop activity of the Erwin Schredinger Institute - which is one of the best Mathematical and Physical Center in Europe!
This Institute played very important role in Scientific life of the world. In order to convince in that it is enough to look on the list of visitors, organizer of the conferences and speakers. This is the list of top experts and specialists in the areas.
This Institute has a special role for Eastern Europe and Russia because it was like a bridge between two parts of traditions. The Austria will lost a great part of it authority in the scientific world especially in the eyes of the specialists in fundamental science in the case of absence of such Institute on the map.
My and my colleagues opinion is that you have to stop and withdraw this decision about the ES-Institute; if you indeed want to keep the authority of Austria as a country which has a high respect of sciences.
Professor Anatoly Vershik,
Mathematical Institute of Russian Academy of Science
ex-persident of St.Petersbrug Mathematical Society.
November 3, 2010.

Wolfgang Schmidt

Sehr geehrte Frau Minister !
Mit grosser Verwunderung, ja mit Bestuerzung habe ich erfahren, dass das Erwin Schroedinger Institut (ESI) ab 1. Januar 2011 nicht mehr finanziell unterstuetzt, also wohl aufgeloest werden soll.
Dieses Institut hat viel fuer die mathematische und physikalische Forschung geleistet. Zahlreiche dort stattfindende Seminare und Tagungen waren hoechst erfolgreich. Sie haben zu wichtigen Ergebnissen oesterreichischer und auslaendischer Forscher gefuehrt. Das Institut hat weltweit hohes Ansehen erlangt.
Als Auslands-Oesterreicher bin ich besonders enttaeuscht, dass ein so erfolgreiches Institut aufgelassen werden soll. Ich bin in den fuenfziger Jahren, als es in Oesterreich noch schlecht ging, in die USA ausgewandert, habe aber die oesterreichische Staatsbuergerschaft behalten. Ich arbeite derzeit mit einem jungen Wiener Mathematiker, Prof. Summerer, an einem Manuskript. Ich habe in den letzten Jahren mit Stolz den Aufschwung der oesterreichischen Wissenschaft vefolgt. Was in Jahren geschaffen wurde, soll nun zerstoert werden? Natuerlich muss jetzt in Oesterreich so wie auch anderswo gespart werden. Eine Etatsverringerung von 10 oder 20 Prozent waehrend der derzeitigen finanziellen Lage waere besser, als ein etabliertes Institut aufzulassen, das dann wohl auf immer weg ist. In vielen Europaeischen Laendern befinden sich mathematische und physikalische Forschungsinstitute. Freilich ist Oesterreich ein kleines Land, aber ich hatte geglaubt, ein Land mit hohem kulturellen Anspruch. Vielleicht habe ich mich darin geirrt. Bedeutet der Name des grossen oesterreichischen Physikers Schroedinger gar nichts? Ich bin sehr traurig. Aber vielleicht ist es noch nicht zu spaet.
Sehr geehrte Frau Minister, ich ersuche Sie hoeflich aber dringlich, das Schroedinger Institut zu erhalten. Sie wuerden als Foerderin der Wissenschaft grossen Dank verdienen.
Mit Hochachtung,
Prof. Wolfgang Schmidt
Österr. Ehrenzeichen fuer Wissenschaft und Kunst
Österr. Akademie der Wissenschaften

American Academy of Arts and Sciences
Polnische Akademie der Wissenschaften
Ehrendoktor Univ.ParisVI,Univ.Waterloo (Kanada), Univ. Ulm, Univ. Marburg
November 9, 2010

Shing tung Yau

We have learned of the decision to terminate funding of Erwin Schrödinger Institute and wish to urge you to reconsider it.
Erwin Schrödinger Institute is one of the truly important mathematics institutes in Austria, with a world-wide reputation.
Many of us have taken advantage of its activities and can attest to its value. Please do not allow this jewel in the crown of Austrian basic science to be lost; if anything, it deserves an increase in funding.
Sincerely yours,
Shing tung Yau,
Chairman,
on behalf of the
Department of Mathematics,
Harvard University.
November 15, 2010

Don Zagier

Sehr geehrte Frau Ministerin,
Wie viele europäische Mathematiker habe ich von der drohenden Schließung des Erwin Schrödinger-Instituts für Mathematische Physik in Wien gehört. Ich habe bereits als einer der Direktoren des Max-Planck-Instituts für Mathematik in Bonn einen Brief zu diesem Thema mit unterschrieben, möchte aber, einfach als betroffener Wissenschaftler, jenem Brief einen persönlichen hinzufügen.
In den Jahrzehnten vor der Gründung des ESI habe ich Österreich nur ein einziges Mal aus wissenschaftlichem Anlass besucht. Seit seiner Gründung bin ich durchschnittlich jedes zweite Jahr nach Österreich gefahren, und zwar immer an das Schrödinger-Institut. Von den rund 20 mathematischen Forschungsinstituten, die ich weltweit kenne, war dies eins der best organisierten, angenehmsten, und wissenschaftlich stimulierendsten überhaupt, mit extrem guten Programmen, die Mathematiker und Physiker von Top-Rang aus der ganzen Welt angezogen haben.
Ich habe gerade erwähnt, dass es in der Welt viele Institute dieser Art gibt. Die ersten großen waren das Institute for Advanced Study in Princeton, das Institut des Hautes Etudes Scientifiques in der Nähe von Paris, das Research Institute of Mathematical Science in Kyoto, das Tata Institute of Fundamental Research in Bombay, und das Max-PlanckInstitut für Mathematik in Bonn (zu dem ich gehöre), aber der Nutzen für die Entwicklung der Wissenschaft wurde immer deutlicher, und es haben sich inzwischen viele andere Länder diesem Trend angeschlossen.
Forschungs-/Gästeinstitute in Mathematik oder in der mathematischen Physik gibt es jetzt auch in England, Irland, Dänemark, Schweden, Spanien, Italien, der Schweiz und (noch) Österreich. In den USA hat man zwei weitere Institute dieser Sorte gegründet, in Deutschland ebenfalls (ein zweites MPI in Leipzig und vor fünf Jahren das Hausdorff-Zentrum in Bonn). China hat in den letzten zehn Jahren drei solche Institute gegründet, und auch Korea und Taiwan haben jetzt jeweils eins.
Man kann leicht übersehen, wie groß - vor allem im Vergleich mit den relativ niedrigen Kosten - der Nutzen eines solchen Instituts für ein Land ist, weil dieser Nutzen indirekt ist. Aber man muss bemerken, dass der Motor von vielen der Entwicklungen, die auch die globale Wirtschaft vorantreiben, aus der Mathematik und der mathematischen Physik kommt. (Um nur 3 Beispiele zu nennen: die Suchmaschine Google beruht auf einem rein mathematischen Algorithmus; das World-Wide-Web entstand aus den Bedürfnissen der Hochenergiephysiker; die Entwicklung, die die Global-Positioning-Systeme so präzise gemacht hat, dass sie sogar für den Einsatz im Autoverkehr verwendbar wurden, kam aus der Zahlentheorie.) Die Länder, die bei dieser Entwicklung mitmachen, haben einen enormen - auch finanziellen - Vorteil gegenüber denjenigen, die ihre Früchte nur importieren. Aber zum Mitmachen muss man junge Leute haben, die in ihrem eigenen Land die entsprechende Ausbildung bekommen und die auch nach dieser Ausbildung nicht durch die uninteressante Wissenschaftslandschaft gezwungen werden, auszuwandern.
Zu dieser Landschaft und dieser Entwicklung gehört der intensive Austausch von Gastwissenschaftlern mit anderen Ländern. Ein Institut zu schließen geht schnell. Eins zu gründen dauert Jahre. Eins zu gründen, das das Niveau und das internationale Ansehen des ESI in Wien genießt, dauert Jahrzehnte.
Ich bitte Sie daher eindringlich, alles Ihnen Mögliche zu tun, um eine Entscheidung abzuwenden, die der Entwicklung und der Visibilität der Wissenschaft von Österreich und von ganz Europa großen Schaden bringen würde.
Mit freundlichen Grüßen
Don Zagier
Wissenschaftliches Mitglied und Direktor,
MPI für Mathematik, Bonn
und Professeur titulaire,
College de France, Paris
November 11, 2010

Eberhard Zeidler

Sehr geehrte Frau Bundesministerin Karl,
seit vielen Jahren hat unser Max-Planck-Institut für Mathematik in den Naturwissenschaften in Leipzig einen engen Kontakt zum Erwin-Schrödinger-Institut in Wien. Als Gründungsdirektor des Max-Planck-Instituts im Jahre 1996 war ich von Anfang an bemüht, enge Verbindungen zum Erwin-Schrödinger-Institut wegen seines hervorragenden internationalen Rufes aufzubauen, und ich habe es mehrfach besucht.
Dieses Institut ist ein internationaler Leuchtturm der Zusammenarbeit zwischen Mathematik und Physik. Die vom ESI organisierten Tagungen zeichnen sich durch internationales Spitzenniveau aus, und nur wenige Institutionen in Europa und in Übersee können mit diesen Tagungen konkurrieren. Vom Präsidenten der Deutschen Mathematikervereinigung, Professor Lück, habe ich erfahren, dass das ESI in großen finanziellen Schwierigkeiten ist. Den beigefügten Brief von Herrn Lück möchte ich voll unterstützen.

Ich bitte Sie, Ihren Beschluss nochmals zu überdenken. Der Schaden für die Wissenschaft wäre beträchtlich.
Mit vorzüglicher Hochachtung
Eberhard Zeidler
(Mitglied des Senats der Nationalen Akademie Leopoldina und Obmann der Sektion Mathematik)
November 9, 2010

Brief des DMV-Präsidenten vom 2. November 2010 an die österreichische Bundesministerin für Wissenschaft und Forschung zur Ankündigung, das Erwin-Schrödinger-Institut nicht mehr zu finanzieren

Sehr geehrte Frau Bundesministerin,
Mit großer Ueberraschung und Bestuerzung haben ich heute nachmittag erfahren, dass dem Erwin-Schrödinger-Institut kurzfristig die Förderungen durch Ihr Bundesministerium gestrichen werden soll. Das Erwin-Schrödinger-Institut ist eines der weltweit renomiertesten Forschungsinstitute fuer Mathematik und Physik und eines der Aushaengeschilder Oesterreichs.
Wir glauben nicht, dass die von Ihnen erhoffte finanzielle Einsparung den Verlust rechtfertigt, den die Schliessung fuer die internationale wissenschaftliche Gesellschaft und insbesondere fuer den Wissenschaftsstandort Oesterreich bedeutet.
Der Vorstand der Deutschen Mathematiker-Vereinigung bittet Sie nachdrücklich, die Ankündigung, das Erwin-Schrödinger-Institut nicht mehr zu finanzieren, zu überdenken. Wenn die Deutschen Mathematiker-Vereinigung irgend etwas tun kann, was Ihnen in Ihrem Entscheidungsprozess hilft, lassen Sie es mich bitte umgehend wissen.
Mit freundlichen Grüssen,
Wolfgang Lueck
(Präsident der Deutschen Mathematiker-Vereinigung)
November 9, 2010

News from the ESI Community

Maximilian Kreuzer 1960 – 2010

Maximilian Kreuzer passed away on November 26, 2010 after having fought an insidious illness for more then two years with great braveness and imperturbability.
Both the Vienna University of Technology and the ESI have lost an outstanding researcher in quantum field theory and the application of algebraic geometry in string theories.
Maximilian Kreuzer served as a member of the Board of the ESI for many years. We will miss his scientific qualities and his friendship.

Max Kreuzer, geboren in Regau am 19. Mai 1960, absolvierte von 1978 bis 1983 an der Technischen Universität ein Doppelstudium der Technischen Physik und der Technischen Mathematik, das er jeweils mit Auszeichnung im Jahre 1982 bzw. 1983 abschloss. Von 1983 bis 1987 arbeitete Kreuzer als Vertragsbediensteter am Institut für Theoretische Physik und promovierte 1986 bei Wolfgang Kummer über vereinheitlichte Theorien der starken, schwachen und elektromagnetischen Wechselwirkungen. In den folgenden Jahren war er Postdoc an der Universität Hannover und Erwin-Schrödinger-Stipendiat an der University of California at Santa Barbara, bevor er 1990 Universitätsassistent am Institut für Theoretische Physik an der Technischen Universität wurde, wo er sich 1993 habilitierte. Im Jahre 1997 wurde Max Kreuzer dort zum Ao. Universitätsprofessor ernannt.

Max Kreuzers wissenschaftliches Werk befasste sich vor allem mit mathematischen Aspekten der Quantenfeldtheorie und Stringtheorie. Er war ein führender Experte in der Anwendung der modernen algebraischen Geometrie in der Superstringtheorie, das ein zentrales Thema der von ihm bis zuletzt mit größtem Einsatz geleiteten Arbeitsgruppe an seinem Institut bildet.

Max Kreuzer war ein engagierter akademischer Lehrer, der in seiner noch so jungen und allzu früh jäh beendeten Karriere zahlreiche Diplomarbeiten und Dissertationen betreute. Viele Jahre war er auch aktiv und erfolgreich in der Pflichtlehre an der TU Wien, u.a. mit der Vorlesung Quantentheorie tätig. Nur wenige Wochen von seinem Tod, bereits schwer gezeichnet von seinem Leiden, ließ er es sich nicht nehmen, selbst noch die Hauptprüfung einer seiner Diplomandinnen abzunehmen.

Max Kreuzer's beachtliche wissenschaftliche Leistungen, sein rückhaltloses Engagement in der Lehre, seine Kollegialität und Bescheidenheit, aber auch seine heroische Tapferkeit und souveräne Gelassenheit, mit der er sein Leiden ertrug, werden uns immer unvergessen bleiben.
(Anton Rebhahn)

——— News from the ESI Administration ———

Alexandra Katzer joined the ESI Administration in November and will be head of the admnistration starting from January 1, 2011.
Maria Marouschek is expecting her second baby and will be on maternity leave until 2012. **Isabella Miedl** will be working part time for the administration from January 1, 2011.

In commemoration of the 50th anniversary of Erwin Schrödinger's death,
ESI is organizing an International Symposium on January 13 – 15, 2011

ERWIN SCHRÖDINGER — 50 YEARS AFTER

in cooperation with the Faculty of Physics, University of Vienna.

Organizing Commitee: Christoph Dellago, Wolfgang L. Reiter, Jakob Yngavason

Honorary Chair: Ruth Braunizer, Alpbach

The Symposium will be accompanied by an exhibition organized by the Österreichische Zentralbibliothek für Physik on the "Life and Work of Erwin Schrödinger" at the premisses of the ESI.[7]

PROGRAMME

Thursday, January 13, 2011

Festvortrag, 19:00 Uhr, Universität Wien, Kleiner Festsaal
(gemeinsam mit der Stadt Wien, Wiener Vorlesung und der Universität Wien)

- Jürgen Renn, Berlin
  Schrödingers Weg zur Wellenmechanik

Friday, January 14, 2011
Location: ESI, Boltzmanngasse 9, A-1090 Wien, Boltzmann Lecture Hall

Lectures

Morning Session: 9:00 am to 12:30 pm

- *Opening*
- Olivier Darrigol, Paris
  A few reasons why Louis de Broglie discovered Broglie's waves and yet did not discover Schrödinger's equation
- Jürg Fröhlich, Zürich
  A Minimalist's View of Quantum Mechanics, Eighty Five Years After Schrödinger's 'Annus Mirabilis'
- Walter Thirring, Wien
  Erwin Schrödinger: Personal Reminiscences

Afternoon Session: 2:30 pm to 5:30 pm

- Birgitta Whaley, Berkeley
  Quantum Coherence and Entanglement in Biology
- Anton Zeilinger, Wien
  The Career of Schrödinger's Entanglement from Philosophical Curiosity to Quantum Information.
- Moty Heiblum, Weizmann Institute
  Neutral Modes - A New Family of Energy Carrier Currentless States

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The lectures are followed by a

Reception at the ESI

at 7:00 pm

[7] Erwin Schrödinger, 12 August 1887, Wien-Erdberg – 4 August, 1961, Wien

Saturday, January 15, 2011

Lectures

Morning Session: 9:00 am to 1:00 pm

- Michel Bitbol, Paris
  Schrödinger's translation scheme between (abstract) representations and facts: a reflection on his late interpretation of quantum mechanics
- Helge Kragh, Aarhus
  A Quantum Discontinuity: the Bohr-Schrödinger Dialogue
- Roberto Car, Princeton
  Quantum mechanics and hydrogen bonds
- Peter Zoller, Innsbruck
  Quantum Computing and Quantum Simulation with Quantum Optical Systems

All friends of the ESI are cordially invited to a Christmas Party at the Institute on Tuesday, December 14, 2010, 5.00 p.m.

Current and Future Activities of the ESI

Thematic Programmes 2010

Topological String Theory, Modularity and Non-Perturbative Physics, June 7 - August 15, 2010

Organizers: L. Katzarkov, A. Klemm, M. Kreuzer, D. Zagier

Anti - de Sitter holography and the quark-gluon plasma: analytical and numerical aspects, August 2 - October 29, 2010

Organizers: A. Rebhan, K. Landsteiner, S. Husa

Higher Structures in Mathematics and Physics, September 1 - November 7, 2010

Organizers: A. Alekseev, H. Bursztyn, T. Strobl

Thematic Programmes 2011

Bialgebras in free Probability, February 1 - April 22, 2011

Organizers: M. Aguiar, F. Lehner, R. Speicher, D. Voiculescu

Nonlinear Waves, April 4 - June 30, 2011

Organizers: A. Constantin, J. Escher, D. Lannes, W. Strauss

Dynamics of General Relativity: Numerical and Analytical Approaches, July 4 - September 2, 2011

Organizers: L. Andersson, R. Beig, M. Heinzle, S. Husa

Combinatorics, Number theory, and Dynamical Systems, October 1 - November 30, 2011

Organizers: M. Einsiedler, P. Grabner, C. Krattenthaler, T. Ziegler

Thematic Programmes 2012

Automorphic Forms: Arithmetic and Geometry, January 1 - February 29, 2012

Organizers: James W. Cogdell, Colette Moeglin, Goran Muic, Joachim Schwermer

K-Theory and Quantum Fields, May 21 - July 27, 2012

Organizers: Matthew Ando, Alan Carey, Harald Grosse, Jouko Mickelsson

Modern Methods of Time-Frequency Analysis II, September 3 - December 9, 2012

Organizers: Hans Georg Feichtinger, Karlheinz Gröchenig

Other Scientific Activities in 2010

Meeting on Optical Response of Extended Systems, November 3 – November 5, 2010

Organizer: K. Hummer

Follow-up workshop to the 2009 ESI programme on "The dbar-Neumann Problem: Analysis, Geometry and Potential Theory", December 13 – December 22, 2010

Organizers: F. Haslinger, B. Lamel, E. Straube

7th Vienna Central European Seminar on Particle Physics and Quantum Field Theory.

Complex Stochastic Dynamics.
November 26 to 28, 2010

This Semininar, organized by the Faculty of Physics, University of Vienna, is supported by the ESI.

Organizer: H. Hüffel

Other Scientific Activities in 2011

Harmonic and Complex Analysis and its Applications, January 10 - 12, 2011

Organizer: H.G. Feichtinger

Erwin Schrödinger Symposium, January 13 - 15, 2011

Organizer: C. Dellago, W.L. Reiter, J. Yngvason, A. Zeilinger

Follow-up workshop to the 2009 ESI programme on 'Selected topics in spectral theory', January 17 - 27, 2011

Organizer: B. Helffer, T. Hoffmann-Ostenhof, A. Laptev

Follow-up workshop to the 2010 ESI programme on 'Quantitative Studies of Nonlinear Wave Phenomena', January 24 - 29, 2011

Organizer: P.C. Aichelburg, P. Bizon, W. Schlag

Seminar on Mathematical Relativity, January 28 - 29, 2011

Organizer: R. Beig, P. Bizon, P. Chrusciel, H. Friedrich

Non-commutative geometry, scattering theory and the Witten index, January 31 - February 4, 2011

Organizer: A.L. Carey, H. Grosse, F. Gesztesy, F. Sukochev

Topological Heterotic Strings and (0,2) Mirror Symmetry, June 20 - 24, 2011

Organizers: J. Distler, J. Knapp, M. Kreuzer, I. Melnikov

ESF Workshop on 'Completely Integrable Systems and Applications', July 3 - 8, 2011

Organizer: G. Teschl

Cartan connections, geometry of homogeneous spaces, and dynamics, July 10 - 23, 2011

Organizers: A. Cap, C. Frances, K. Melnick

Summer School in Mathematical Physics, August 15 - 25, 2011

Organizers: C. Hainzl, R. Seiringer

Rigorous Quantum Field Theory in the LHC Era, September 20 - October 1, 2011

Organizers: C. Jäkel, C. Kopper, G. Lechner

Erwin Schrödinger Lectures

Spring Term 2011

The Erwin Schrödinger Lectures are directed towards a general audience of mathematicians and physicists. In particular it is an intention of these lectures to inform non-specialists and graduate students about recent developments and results in some area of mathematics or mathematical physics.

These lectures take place in the Boltzmann Lecture Room of the ESI.

Each lecture will be followed by an informal reception at the Common Room of the ESI.

Anne Kox (University of Amsterdam):
The Correspondence between H. A. Lorentz and E. Schrödinger
January 20, 2011, 5:00 p.m.

This lecture is organized in co-operation with the Institute Vienna Circle

Senior Research Fellows Lecture Courses

Spring Term 2011

To stimulate the interaction with the local scientific community, the ESI offers lecture courses on an advanced graduate level. These courses are taught by Senior Fellows of the ESI, whose stays in Vienna are financed by the University of Vienna, the Vienna University of Technology, and the Austrian Federal Ministry for Science and Research.
These courses take place in the Erwin-Schrödinger Lecture Room of the ESI.

Michael Baak (Universität Bielefeld, Fakultät für Mathematik)

Aperiodische Ordnung/Dynamische Systeme in Physik und Biologie,
April 1 - June 30, 2011,
Lectures: time tba,
Seminar: time tba

Bruna Nacht (University of California, Department of Mathematics)

title of lecture - tba,
March 1 - June 30, 2011,
Lectures: time tba,
Seminar: time tba

Guest of the Senior Research Fellows 2011:
Robert Sims (University of Arizona, Department of Mathematics)
June 1 - June 30, 2011

Lectures on Physical and Mathematical Sciences in Historical Context

Anne Kox (Amsterdam)
The Correspondence between H. A. Lorentz and E. Schrödinger
January 20, 2011

Previous lectures:

2005:

Leo Corry (The Cohn Institute for History and Philosophy of Science and Ideas, Tel-Aviv University):
Hilbert's Axiomatic Approach to the General Theory of Relativity: From "Grundlagen der Geometrie" to "Grundlagen der Physik"

Jeremy Gray (Centre for the History of the Mathematical Sciences, Faculty of Mathematics, Open University, Milton Keynes, U.K.):
Poincaré and Fundamental Physics

2006:

Catherine Goldstein (CNRS, Paris, Institut mathèmatique de Jussieu):
Geometry and Nature according to A. N. Whitehead

2007:

Dieter Hoffmann (Max Planck Institut für Wissenschaftsgeschichte, Berlin):
Zwischen Autonomie und Anpassung. Die Deutsche Physikalische Gesellschaft im Dritten Reich.

Moritz Epple (Universität Frankfurt):
Beyond Metaphysics and Intuition: Felix Hausdorff's View on Geometry

2008:

Scott Walter (Archives Henri Poincare, Nancy):
Hermann Minkowski and the Scandal of Spacetime

Jacques Bouveresse (Collège de France, Paris):
Ludwig Boltzmann und das Problem der Erklärung in der Wissenschaft

2009:

Scott Walter (Archives Henri Poincaré, Nancy)
Hermann Minkowski and theoretical physics in Göttingen

Samuel J. Patterson (Göttingen)
The number theorist Hermann Minkowski

Nevena Ilieva-Litova (Bulgarian Academy of Sciences)
Pauli and the non-Abelian gauge theories: between physical intuition and mathematical logic

"In the first place God made idiots; this was for practice. Then he made evangelists." Mark Twain

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