## Prof. Jarah Evslin

RECENT RESEARCH ACTIVITIES

Since 2001 my research has been focused in three directions. With Kenichi Konishi, Hitoshi Murayama, Alexei Yung and a number of students I have written a series of papers on nonabelian monopoles, which are monopoles charged under unbroken nonabelian symmetries, and their confinement by nonabelian vortices in gauge theories with N = 2 supersymmetry softly broken to N = 1 by a polynomial superpotential. We have constructed Bogomolny equations satisfied by BPS monopoles and vortices and counted the solutions, in particular showing that, as Goddard, Nuyts and Olive conjectured 25 years ago, nonabelian monopoles can only be charged under the dual gauge group. This allows them to escape a no-go theorem by Sydney Coleman and others. We found that the worldvolume theory of the vortices is a linear sigma model and used mirror symmetry to study its vacua and thus demonstrate that the gauge symmetry broken by a classical vortex configuration is restored in the quantum vacuum. We found that various combinations of Fayet-Iliopoulos terms and superpotentials lead to monopoles confined by either 0, 1 or 2 vortices and computed the tensions of these vortices, and the conditions under which the two vortices confining a single monopole may be mutually BPS. Continuing with Stefano Bolognesi, who is now in Copenhagen, we found a classification of the stable vortices and unconfined monopoles in any gauge theory that may be constructed from an M-theory brane cartoon, which includes the theories I had considered with the Pisa group. One might think that the branes and fluxes of string theory would, like their cousins in higherform abelian gauge theories, be classified by (co)homology. However Freed and Witten (FW) and have shown that worldsheet fermions and spacetime Chern-Simons terms lead to anomalies that are cured by brane insertions, which implies that the inserted branes are unstable. This is dual to the familiar fact that a vortex that confines a particular charged particle may decay via pair production of that particle. Thus the FW anomaly eliminates certain (co)homology classes from the spectrum while rendering others unstable. The configurations that remain (unconfined charges and sourceless fluxes), quotiented by the unstable ones, are classified by K-theory. The K-theory classification is incorrect, for example it does not respect the S-duality covariance of type IIB string theory. Using the S-duals of FW anomalies to identify a more complete set of confined and unstable pairs of states, I have constructed a duality covariant set of conserved charges. This set classifies, for example, universality classes of gauge theories in the KlebanovStrassler cascade whereas the usual K-class is not an RG-invariant. Peter Bouwknegt, Varghese Mathai and I have found the full consistency condition on the 3-forms, which is a correction to the tadpole cancellation condition popular among model-builders. Ultimately K-theory and its cousins fail to classify fields and branes because the self-duality of the fluxes halves the number of independent field strengths. A very different scheme does not suffer from this double counting, Witten's E8 principal bundle fibered over the 11-dimensional M-theory spacetime. While the physical nature of the bundle remains a mystery, Allan Adams 1and I have shown that the Freed-Witten anomalies and also the confinement pattern of massive IIA are precisely the obstructions to the existence of this bundle. Compactifying M-theory on a 2-torus one finds that the set of flat connections of the E8 bundle over the

2-torus is the physical IIB circle. Bouwknegt, Mathai and I have found that the identification of this E8 circle with the IIB circle solves an old problem. T-duality can change the topology of spacetime, and this identification shows that not only is there always a dual topology, but that T-duality relates circle bundles over the same space. Each circle bundle is characterized entirely by a curvature, which we show is just the integral of the dual NS 3-form flux over the dual circle. We have proven that this construction induces an isomorphism of the respective twisted K-theories. Recently our result has become popular among those studying generalized Calabi-Yau's as the side of the duality with NS flux is not Calabi-Yau. Since my arrival in Brussels, the home of the Prigogine school of thermodynamics and of BRST I have engaged in two very different projects. First, with Giorgio Sonnino, a professor at the European Commission, I have constructed a covariant geometric formulation of thermodynamics in which relaxing thermodynamic systems follow geodesics in the space of thermodynamic configurations. My second project, which I performed alone, but with considerable consultation from the groups at Brussels, Pisa and Munich, is more relevant to the proposal at hand. Thirty years ago Unruh conjectured that accelerating observers in a vacuum will see a thermal spectrum of radiation of all free fields that are present in the theory. Today this conjecture is universally accepted and is known as the Unruh effect. I noted that the Unruh effect implies that unphysical polarizations of the photon will also be excited, which is clearly impossible. I explained this prediction in terms of BRST. Any physical state must have vanishing BRST charge, but in general relativity an eternally accelerating observer sees a horizon and, while the BRST charges on both sides of the horizon must cancel, the BRST charge in the part of the universe which to him is observable is nonzero and so he observes a nonphysical state. I further showed that a particular transformation which is a gauge transformation from the perspective of an inertial observer can make the BRST charge vanish separately on both sides of the horizon.