Plotting with Stanley Mandelstam, visas from Nicole and trombones with Eugène: My times at LPTENS

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Invitation

In the spring of 1980, I had spent an initial postdoctoral period of 3 years in London – firstly for a year at Kings College, then two years at Imperial College, and I was about to head to CERN for a year as a non-member-state postdoc.

At Imperial, Peter West and I had written a series of papers on the off-shell formulation of $N = 1$ supergravity, starting with finding the minimal system of auxiliary fields required for this Phys.Lett.B 74 (1978) 330 and following on with development of the tensor calculus for supergravity which was necessary for the general construction of supergravity-supermatter couplings

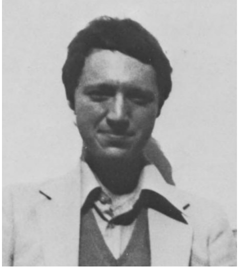
Nucl.Phys.B 140 (1978) 285-293, Phys.Lett.B 77 (1978) 376, Nucl.Phys.B 145 (1978) 175 .

These developments took place in parallel with related work going on at the École Normale, leading to the general coupling and spontaneous supersymmetry breaking results presented in two papers by Eugène Cremmer, Bernard Julia, Joel Scherk, Sergio Ferrara, Luciano Girardello, and Peter van Nieuwenhuizen

Phys.Lett.B 79 (1978) 231, Nucl.Phys.B 147 (1979) 105 .

Back in 1980, we didn't have the internet yet, but at Imperial there was already a proto-system. Down at the end of the hall, Abdus Salam had a telephone and he was in regular communication with the whole world of physics. So somehow, Peter and I, two young postdocs, got to be known by our scientific elders. I never learned how it happened, but somehow, just at the time I was preparing to go to CERN, I got a letter from Joel inviting me to come to the ENS after my year at CERN. A spontaneous follow-on postdoc offer was extremely welcome at that point in my career!

Sadly, I never got to collaborate with Joel, because he passed away in May of 1980.



Six months at LPTENS

After my year at CERN, I arrived at the École Normale in the autumn of 1981, looking forward to my time in Paris – both for science and for life in this wonderful city. Here I spent six very productive months, mainly working with Paul Townsend, who came at the same time and also with Paul Howe at CERN, but also with Riccardo Barbieri, Sergio Ferrara and Dimitri Nanopoulos.

Together with $(\text{Paul})^2$, we established an off-shell formulation of maximal $N = 4$ super Yang-Mills theory using Feynman rules for $N = 2$ supersymmetry and we used this to give the first Feynman-rule proof of the ultraviolet finiteness of the $N = 4$ theory Nucl.Phys.B 214 (1983) 519, Nucl.Phys.B 236 (1984) 125 . Some four months after our preprint was sent out, Stanley Mandelstam gave a different proof using light-cone Feynman rules.

In April 1982, I had to leave Paris earlier than I would have wanted because I had been awarded an SERC 5-year fellowship back at Imperial College, which had to be taken up by that time at the latest.

Stanley and the plot for Nicole

In the summer of 1982, Julius Wess invited me and Stanley Mandelstam to speak about the $N = 4$ finiteness in his session of the 21^{st} International Conference on High Energy Physics, back once again in Paris. This was my opportunity to get to know Stanley, and this also led to a collaborative administrative manoeuvre involving the two of us.

Anybody who had ever been at the École Normale quickly learned that essentially everything which happened here happened through the magic of Nicole Ribet – appointments, combinations of postes roses with other partial sources of funds, and, together with Eugène Cremmer, the whole social atmosphere of the Institute.

For mysterious CNRS reasons, however, one thing Nicole couldn't do easily was to get herself promoted. So this led to Stanley and I joining forces in a supportive letter explaining Nicole's amazing abilities, and in the end this seemed to help, because the promotion came through sometime later. And I got to know and appreciate Stanley Mandelstam.

Nicole and the Ribet Visa

Over the following years, I returned to the ENS many times, often to attend the Instituts d'Été, usually organised in the beginning by Eugène, then later organised together with the various Marie Curie networks we had under the capable hand of Toine Van Proeyen.

The old Institut Henri Poincaré gave way (some time around 1990?) to a new incarnation as a center for longer semester "thèmes". I was asked to be Director of such a semester, acting together with Ignatios Antoniadis and Eugène, taking place from September 2000 to January 2001, entitled "Supergravité, Supercordes et Théorie M" in the Centre Émile Borel of the IHP. For this, see our overview article "Les Supercordes"

Gazette des mathématiciens 2001, Janvier, 87, pp. 17; Avril, 88 (2001).

However in order for me, just some colonial American, to be allowed to be a Director of a historic French institution, I needed an appropriate Visa. Here Nicole came to the rescue. She had spearheaded[1] with a *projet de loi* in the French Parliament to allow for special intermediate-term scientific visas for situations such as mine. This saved me and many others from considerable administrative grief and allowed for just such itemporary positions in France.

Visa Brezin-Ribet-Meyer

[1] Actually, in conspiracy together with Edouard Brezin and Phillipe Meyer.

ELSEVIER

Nuclear Physics B 520 (1998) 132–156

NUCLEAR PHYSICS B

Spectrum-generating symmetries for BPS solitons ☆

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Abstract

We show that there exist non-linearly realised duality symmetries that are independent of the standard supergravity global symmetries, and which provide active spectrum-generating symmetries for the fundamental BPS solitons. The additional ingredient, in any space-time dimension, is a single scaling transformation that allows one to map between BPS solitons with different masses. Without the inclusion of this additional transformation, which is a symmetry of the classical equa-

Eugène and the Trombone

E. Cremmer, H. Lü, C.N. Pope and K.S.S., Nucl. Phys. B 520, 132 (1998)

One of the problems I worked on together with Eugène, and with Hong Lü and Chris Pope, was to find the correct form of duality transformations generating orbits of form-field charged solutions (such as monopoles and branes) with a *fixed* asymptotic geometry and fixed asymptotic matter fields. This was clearly related to the famous Cremmer-Julia symmetries:

D	G	H
9	$GL(2,\mathbb{R})$	$SO(2)$
8	$SL(3,\mathbb{R}) \times SL(2,\mathbb{R})$	$SO(3) \times SO(2)$
7	$SL(5,\mathbb{R})$	$SO(5)$
6	$SO(5,5)$	$SO(5) \times SO(5)$
5	$E_{6(+6)}$	$USp(8)$
4	$E_{7(+7)}$	$SU(8)$
3	$E_{8(+8)}$	$SO(16)$

Supergravity symmetry groups.

These symmetries act not only on the form fields, however, but also on the G/H manifolds of scalar fields, changing also the asymptotic scalar values. How to obtain the charge orbits for solutions with fixed asymptotics got us involved in some issues typical of the sorts of things Eugène liked very much.

The key point to recognise is that for any of the maximally-noncompact supergravity symmetry groups G shown in the table, one has an Iwasawa decomposition of a general group element Λ, specialised to the vacuum point on the scalar modulus manifold G/H and to the charges Q defining a given fundamental soliton solution:

$$\Lambda = \mathbf{B}\,\mathbf{H}\ ,$$

where $\mathbf{H}$ is an element of the stability group H of the vacuum modulus point $\mathcal{M}_0$ on G/H and $\mathbf{B}$ is an element of the Borel subgroup corresponding to the charge Q, which has the property that it leaves Q invariant up to a rescaling.

So the basic idea is to first perform a standard supergravity Cremmer-Julia transformation that moves the charge Q to the intended target value on the solution orbit, but which also, unwantedly, moves the scalar field moduli (*i.e.* the scalar asymptotic values). The scalar moduli are then returned to their original values by the Borel transformation B. This also transforms the charges Q again, but now only by a rescaling.

The final step is to undo the rescaling of the charges Q by a symmetry transformation similar to the one in pure GR which moves the Schwarzschild solution along its orbit of different masses. One starts with the "trombone" symmetry of the equations of motion, under which the action is not invariant but scales homogeneously. In $D = 11$ supergravity, the transformations of the metric and 3-form field are

$$g_{\mu\nu} \longrightarrow \lambda^2 g_{\mu\nu} \ , \qquad A_3 \longrightarrow \lambda^3 A_3 \ ,$$

under which the Lagrangian scales as $\mathcal{L} \rightarrow \lambda^9 \mathcal{L}$.

Of course, such a trombone transformation also scales the asymptotic value of the metric, which is not wanted either. In order to return the asymptotic metric to its original value (*e.g.* Minkowski space at transverse infinity), one can however finish the construction with a simple general coordinate transformation.

This is how one generates *active* duality transformations moving a given starting brane or monopole solution along a charge orbit while holding all the asymptotic fields (the metric and the scalar moduli) constant. The trombone followed by the final general coordinate compensator leaves the asymptotic values of the metric and scalar fields unchanged, but it does change the mass or tension of the solution, so the active-symmetry orbit contains physically distinct solutions.

This is the classical situation. At the quantum level, Dirac quantisation restricts the $G(\mathbb{R})$ symmetry to $G(\mathbb{Z})$ and one should also be concerned about anomalies in the construction, especially possibly involving the trombone symmetry.

We showed nonetheless that the leading-order variation vanishes for the first non-vanishing-on-shell quantum correction (of structure curvature^4 like the 3-loop Bel-Robinson^2 supergravity counterterm S. Deser, J.H. Kay & K.S.S., Phys.Rev.Lett. 38 (1977) 527; 1506.03757), thus preserving, at least to this order, the active-symmetry structure.

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Eugène was an essential part of the spirit of the ENS in all my times here. It was always he who gathered us together for lunch chez Jean-Pierre at Les Bugnes or on the Rue d'Ulm (with wine! – one had to learn how still to get something done in the afternoon!). And, together with Nicole, and despite all the complexities of CNRS administration, it made for a truly stimulating environment in which to work. These are some of my cherished memories of the very productive times I have spent at the ENS.


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