

SUPERSYMMETRY'S START AND OTHER SUBTLITIES

Motivated by the article of Savas Dimopoulos, Stuart A. Raby and Frank Wilczek on supersymmetry (October 1991, page 25), I write this letter to offer some perspective on the origins of supersymmetry. Those authors are of course more interested in describing the possible application of space-time supersymmetry in four dimensions, and rightfully so, but I do not think they do justice to the origins of the ideas, which were in part motivated by the formulation of the first superstring theory.

I must say, however, that as early as 1966, H. Myazawa¹ tried to incorporate the baryon and meson SU(6) multiplets into the same mathematical structure. In the process, he invented a supersymmetric current algebra as well as the supergroups in the series SU(m/n); he was able to fit these multiplets into SU(6/21). We would now call this a nonrelativistic application of supersymmetry, to be distinguished from supersymmetry as a space-time symmetry. To my knowledge this work went ignored for many years. I myself learned of it from Feza Gürsey in 1987.

At the same time in the West, the idea of duality in pion-nucleon scattering and the dual resonance model motivated many to search for a symmetry between fermions and bosons. In 1971 I presented a generalization of the Dirac equation to strings that only described space-time fermions;² it was shortly followed by the work of André Neveu and John H. Schwarz,³ who formulated the bosonic side of the theory, leading to the first superstring theory. Both formulations had a novel symmetry on the string world sheet: supersymmetry, acting between the time and space coordinates of the world sheet. In 1974 Julius Wess and Bruno Zumino, based on their studies of two-dimensional supersymmetry found in these models, realized that this new space-time symmetry could be used in the context of a four-dimensional local field theory, thereby ditching all its superstring parentage. This provides the starting point of the article. By a quirk of fate, it was two years later

that, influenced by these developments, F. Gliozzi, Joël Scherk and David Olive⁴ proved that under some circumstances, the two sectors of the first superstring theory were in fact superpartners in a ten-dimensional space-time.

I am not as familiar with the Russian path to supersymmetry. Many years ago Pavel Winternitz showed me the proceedings of a Russian summer school, *circa* 1966, where a current algebra with both commutators and anticommutators appeared. It seems that the late F. A. Berezin, through his pioneering attempts at extending analysis to superspace, motivated many Russian researchers of his generation in the direction of supersymmetry.⁵ Relativistic supersymmetry in four dimensions was first formulated by Y. A. Gol'fand and E. P. Likhtman in 1971 and by D. V. Volkov and V. P. Akulov in 1973. Their work, like Myazawa's, went unheeded, as evidenced by the scarcity of follow-up articles. I apologize for my incomplete knowledge of these important developments.

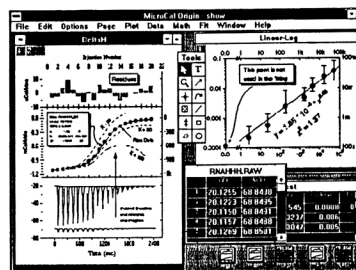
Sociologically at least, the path to supersymmetry was first defined by superstring theory. I also should add that until a credible mechanism for supersymmetry breaking is found, the theory cannot be viewed as complete. In my view, it is quite likely that an understanding of the mechanism that breaks supersymmetry will lead back to ten-dimensional superstrings, most likely the heterotic superstring.

Finally, let me make one last historical comment, this time concerning the origin of QCD. Dimopoulos, Raby and Wilczek fail to mention the pioneering work of M. Y. Hahn and Yoichiro Nambu,⁶ who proposed in 1965 a Yang-Mills description of the strong interactions with eight gluons, although they did so in the context of integrally charged quarks—that is, they were wrong by order α , where α indicates photon interactions. In the Hahn-Nambu scheme, gluons had electric charge and thus interacted with photons. If $\alpha = 0$, then their theory coincides with modern QCD!

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References

1. H. Myazawa, *Prog. Theor. Phys.* **36**, 1266 (1966); *Phys. Rev.* **170**, 1586 (1968).
2. P. Ramond, *Phys. Rev. D* **3**, 2415 (1971).
3. A. Neveu, J. H. Schwarz, *Phys. Rev. D* **4**, 1109 (1971).
4. F. Gliozzi, J. Scherk, D. Olive, *Nucl. Phys. B* **122**, 253 (1977).
5. See A. A. Kirillov, introduction to F. A. Berezin, *Introduction to Algebra and Analysis with Anticommuting Variables*, Moscow (1983), in Russian. I am grateful to J. Patera for his kind translation.
6. M. Y. Hahn, Y. Nambu, *Phys. Rev. B* **139**, 1006 (1965).

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The article on unification of couplings by Savas Dimopoulos, Stuart A. Raby and Frank Wilczek is very beautiful and clear, so let me just point out a slight historical inaccuracy. The authors remark parenthetically that "the Higgs mechanism is ... a relativistic version of Fritz and Heinz London's superconducting electrodynamics."

I believe the real antecedent of the Higgs mechanism is the Debye-Hückel theory of screening of charge in electrolytes;¹ in this theory one sees explicitly how the $1/r$ in Coulomb's law is changed to Hideki Yukawa's $\exp(-r/b)/r$, which translates relativistically into giving mass to the gauge boson. Also, the superconductivity analogy should be credited to Philip W. Anderson;² it is very cryptic in the Londons' work.

References

1. P. Debye, E. Hückel, *Phys. Z.* **24**, 185, 305 (1923).
2. P. W. Anderson, *Phys. Rev.* **110**, 827 (1958); **130**, 439 (1963). Both papers are reprinted in E. Fahri, R. Jackiw, eds., *Dynamical Gauge Symmetry Breaking*, World Scientific, Singapore (1982).

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Figure 4 on page 28 of the October issue is said to represent screening that will lessen the electric field at large distances. A simple application of Gauss's law will show that a spherical configuration of dipoles surrounding a charge as shown produces no change in the electric field at large distances.

Since I am writing, permit me to express my admiration for Frank Wilczek's poetry.

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Is 'Workshop Physics' Not the Real Thing?

Priscilla W. Laws (December, page 24) writes about the Workshop Physics approach being used at Dickinson College. Since this approach is typical of a trend that is developing both at the college level and at the high school level, where most of my own teaching experience has been, it warrants a response. I believe this approach to be misconceived because it ultimately fails to convey the most important concepts that should be gained from an introductory physics sequence. The use of computers is in part the cause of this failure, which the computer usage then tends to disguise by creating an aura of sophistication.

Consider, for instance, Laws's description, given as an example of a beneficial outcome, of how a physics major arrived at the solution to a two-dimensional trajectory problem. The student recognized an analogy between horizontal wind gusts acting on a rocket and the sideways taps she had made on a moving bowling ball during an experiment. Although she was insightful in making this connection, her inability to solve the problem until she had thought of this analogy makes it evident that she had not yet grasped the fundamental idea of independent vector components.

Likewise, one of Laws's figures shows a spreadsheet analysis of student-obtained free-fall data that does, indeed, yield a straight-line distance-versus-time-squared graph, but only after the data have been linearized. It is unlikely that students who are described as still having trouble interpreting graphs would understand linearization. The computer is not just performing some tedious details. The computer calculations are obscuring those very details that the students need to work with, think about and finally understand. Working directly with a meter stick, a spark timer tape and a piece of graph paper would show much more immediately how the time-squared linearity arises from the fact that as time progresses the additional distance that the object falls during each time interval is itself increasing at a constant rate.

Similar concerns arise in regard to the use of computers in conjunction with teaching electric fields. A field mapping simulation, by the very virtue of the fact that it gives a result automatically, precludes the students from having to think about the underlying connections between charge distributions and the resulting flux

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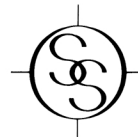
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