Hans Kastrup

Duplantier, B., Rivesseau, V. (eds.):
Vacuum Energy – Renormalization


French mathematicians have established a number of influential “Séminaires” in the past, the most famous one being the “Séminaire Bourbaki,” the associated publications of which contain numerous original and important contributions. Under the impression of those successes theoretical physicists from Paris recently created a corresponding “Séminaire Poincaré” in order to discuss important topics in theoretical physics. The first two of these seminars took place in 2002. The contributions of the speakers are published in the present volume, edited by Bertrand Duplantier (first seminar) and Vincent Rivesseau (second seminar).

The topic of the first seminar was “vacuum energy,” the modern quantum variant of the old “ether.” Unknowingly Einstein contributed essentially to the modern resurrection of the phantom he had buried previously through his Special Relativity by introducing the cosmological $\Lambda$-term into his equations of General Relativity. In doing so Einstein was aiming at a static cosmological solution of his equations. When the expansion of the universe was discovered, Einstein dissociated himself from the “cosmological term.” According to George Gamov “he remarked that the introduction of the cosmological term was the biggest blunder he ever made in his life.” [G. Gamov, My world line. An informal autobiography (The Viking Press, New York, 1970), p. 44.] In 1967 Zel’dovich pointed out that Einstein’s $\Lambda$-term could be induced by the vacuum fluctuations of the energy momentum tensor of quantized matter fields. However, rough estimates yield values which are outrageously larger than astrophysical observations would allow for. This discrepancy, unparalleled in the realm of physics, is presently the subject of many controversial speculations. In his introduction to the seminar Thibault Damour says appropriately that for a long time the cosmological constant has been “le Monstre de Loch Ness de la cosmologie.” The recent astrophysical observations, especially the remarkable results from the WMAP, show that the energy...
density associated with the $\Lambda$-term is of the same order of magnitude as the matter density in the present epoch. Thus, that heavily discussed and disputed term in Einstein’s equations appears to be non-vanishing. Other manifestations of vacuum energy fluctuations are: the van der Waal’s forces, the modification of weak electromagnetic fields due to virtual electron-positron pair fluctuations and the Casimir effect.

All these effects have been discussed in the first seminar: N. Straumann gives an elaborate and interesting historical introduction into the subject, discussing especially the astrophysical aspects of the vacuum energy. At the time of the seminar the very impressive WMAP data from 2003 were, unfortunately, not yet available and so the comparison with experiments is still preliminary. B. Duplantier gives an introduction to the Casimir effect, emphasizing its thermodynamical properties. R. Balian discusses the strong dependence of the Casimir effect on the shape of the geometric boundaries and on the Dirichlet and Neumann boundary conditions for the fields. A. Aspect and J. Dalibard report on the recent experiments concerning the Casimir-Polder-Lifshitz problem, where a neutral polarizable atom is placed opposite a metallic or dielectric wall which modifies the vacuum fluctuations of the radiation field in infinite space and which leads to mirror forces on the induced atomic dipole. Experiments concerning the Casimir effect are discussed by A. Lambrecht and S. Reynaud. Geometry and temperature dependences and their comparison with theoretical predictions are still an experimental task for the future. Finally M.S. Turner discusses problems associated with the non-vanishing “dark energy,” i.e. the non-vanishing $\Lambda$-term. In hind-sight this discussion, too, suffers from the fact that the WMAP data were not yet available. Nevertheless, one of the most important questions is still unanswered: Why is the dark energy density of the same order of magnitude as the matter energy (mostly dark one) now?

All talks taken together give an interesting outline of the remarkable physical properties of what sometimes is misleadingly called “vacuum,” but what actually are manifestations of the quantum fluctuations of the ground state energies of given systems. This fact was taken quite seriously by the generation which founded quantum mechanics, often more so than by later ones (in his unpublished 1964/65 Princeton lecture notes on QED A. Wightman said: “For the old boys, the vacuum ‘boils’...”).

The second seminar was devoted to “Renormalization.” Though the concept plays an important role in several branches of physics, it has a considerable technical and formal (mathematical) flavour which does not always have a direct physical appeal. Nevertheless, V. Rivasseau, editor and contributor of an interesting introduction to the impressive history of the concept, in his conclusions endeavours to say “that the renormalization group is in some deep sense the ‘soul’ of physics.” In his introduction Rivasseau let the renormalization history start with “Bogoliubov and followers.” Actually, the modern story of renormalization in quantum field theory started at the famous June 1947 Shelter Island Conference, when the suggestion by H. A. Kramers to compensate the notorious infinities of perturbation theory by an unphysical initial bare mass and keep only a physical mass parameter in the final observable expressions, led H. A. Bethe to a first calculation of the just discovered Lamb shift [for details see S. S. Schweber, QED and the men who made it: Dyson, Feynman, Schwinger, and Tomonaga (Princeton University