# Stanley Mandelstam

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Stanley Mandelstam: the early years at a 'Most Stimulating Theoretical Group'

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After a childhood spent in the small town of Glencoe in the Natal Midlands of South Africa, and schooling in the neighbouring town of Dundee, Stanley Mandelstam went to read chemical engineering at Witwatersrand, Johannesburg completing his study with a B.Sc. in 1952. This subject appears to have been a choice of reason initiated by his mother who had encouraged Stanley to opt for a vocational degree.[1] It was not until he moved to Cambridge that he found what his nephew Ian Abramson would later call his 'first love', namely mathematical physics. This would remain his personal vocation and all his future studies and work were in this field. Mandelstam completed a physics degree at Cambridge in 1954[2] and then moved to the University of Birmingham which, at the time had what was later described as 'the most stimulating theoretical group in the world' around Rudolf Peierls.[3] It is his time at Birmingham between 1954 and 1957 and his short spell as Professor of Mathematical Physics there between 1960 and 1963 as well as the interim three years at Columbia and Berkeley that this brief paper will focus on.

When Rudolf Peierls took up his newly-created Chair in Mathematical Physics at the University of Birmingham in 1937, the university had no theoretical physics to speak of. Less than two decades later, Birmingham was considered as THE go-to place to study and research the subject. It was a vibrant place led by 'Prof' as Rudof Peierls was affectionately referred to by his postgraduate students and junior colleagues. Most likely it was this vibrancy and the unusual concentration of impressive talent at Birmingham that attracted the young South African to join the group after his stint at Cambridge. By 1954, when Mandelstam considered his options for graduate study, the Department of Mathematical Physics, as it was known then, had firmly established itself in the international teaching and research landscape. And in

[1] 'Remembering Stanley Mandelstam, http://physics.berkeley.edu/news-events/news/20160629/remembering-stanley-mandelstam-1928-2016 (accessed 6.10.2016).
[2] Most sources state that he competed a B.A. Peierls mentions to colleagues that it was a part III in physics, the degree that would be the standard entry route for prospective PhD students at Birmigham in this field. Letter Rudolf Peierls to John Cockroft, 10 August 1959, in Lee, S., *Sir Rudolf Peierls. Selected and Scientific Correspondence*, vol. 2 (London et al.: World Scientific Press, 2009) (hereinafter *Peierls Correspondence*) letter 676.
[3] Brown, G.E., "Fly with Eagles.", *Ann. Rev. Nucl. & Part. Sci.* 51, (2001): 1.

fact, the names of physicists moving in and out of the department in that period read like a who is who in physics: Freeman Dyson, Sam Edwards, Julian Schwinger, Dick Dalitz, Nina Byers, Gerry Brown, Ed Salpeter, James Langer, Brian Flowers, John Bell, Paul Matthews, Denys Wilkinson, Elliot Lieb to name but a few.

If Mandelstam was impressed with Prof and Birmingham, the latter was similarly impressed with Mandelstam. He described him as 'very bright'[4] and 'promising'[5] while at the same time being 'charming' and 'educated'. Prof. was very keen to foster his career by enabling him to participate in the lively research exchange that had been developed between Peierls and some of his American colleagues, most notably Hans Bethe at Cornell, but also Freeman Dyson at Princeton or Robert Serber at Columbia. A letter from Peierls to Robert Serber, in which he summarized Mandelstam's remarkable achievements, demonstrates clearly that Peierls, who was not known for being impressed easily, found Mandelstam's work extraordinary. Not only had he completed the theoretical physics course at Cambridge in two years, not a mean feat in itself for someone from an engineering rather than physics background; he had also completed the academic requirements for a Ph.D. at Birmingham in only two years. Mandelstam had done so by publishing two important papers in formal field theory, which dealt with the nature of the solutions to the Bethe-Salpeter equation. The first of these papers, "Dynamical variables in the Bethe-Salpeter formalism",[6] was published within a year of commencing his research, and by Prof's own admission, he would have awarded him a PhD for this achievement only, had the regulations permitted this.[7] The second paper, an extension of his earlier work, was published shortly afterwards,[8] and his doctoral duely awarded.
That Peierls held him in high regard also beyond the formal field theoretical work, is clear in his comments about Mandelstam's subsequent research, a more phenomenological approach of interpretation of high energy experiments. This work had been facilitated by a UK government grant relating to data collection and interpretation of experiments at the high energy lab at the University of Cambridge, specifically the meson production in *p-p*

[4] Letter Rudolf Peierls to R.H.Dalitz, 4 April 1955, *Peierls Correspondence*, letter 610.
[5] Rudolf Peierls to Robert Serber, 6 December 1956, *Peierls Correspondence*, letter 642.
[6] Mandelstam, Stanley. "Dynamical variables in the Bethe-Salpeter formalism." *Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*. Vol. 233. No. 1193. The Royal Society, 1955.
[7] Rudolf Peierls to Robert Serber, 6.12.1956, *Peierls Correspondence*, letter 642.
[8] Mandelstam, S. "Uniqueness of solutions of the Bethe-Salpeter equation for scattering." *Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*. Vol. 237. No. 1211. The Royal Society, 1956.

collisions combining phase-space arguments with the picture of the isobaric states and linking the results with experimental work at Birmingham.[9]

The glowing reference provided by Peierls in the above-cited letter to Robert Serber had the desired effect, and in late 1957, Mandelstam joined Serber's department at Columbia as a Boese fellow, before – a year later - moving on to Berkeley. Berkeley would become his home for most of the the subsequent half century first as Professor of Physics and upon his retirement in 1994 as emeritus.

From Columbia, he engaged in a regular and intensive exchange of letters with Prof. The tone and substance of these letters bears witness to both the scientific and the non-scientific interests and accomplishments of both scholars. Shortly after arriving in New York, Mandelstam reported back about the many 'distractions' that the city that never sleeps had on offer – very much in contrast to Birmingham which still suffered from post-war austerity. He talked of concerts, theatre, and art galleries which clearly fascinated him. Yet, first and foremost, his correspondence – not surprisingly – comprised the newest developments in physics.

The most exciting research, Mandelstam reported, took place in Jack Steinberger's bubble chamber group.[10] The activities of the bubble chamber program at Columbia were concentrated around the Nevis Laboratories at the Physics Department, though many early pictures analysed there had been taken at the Brookhaven National Laboratory, initially at the Cosmotron (1952-1966) and later (from 1960, i.e. after Mandelstam's time at Columbia) at the Alternating Gradient Synchrotron. The program had been initiated by Jack Steinberger in 1956 – just prior to Mandelstam's arrival in the US, and the excitement among the young scientist about the work of this group was palpable. And the enthusiasm would later be shared by the Nobel Committee which would award Steinberger, Leon M. Lederman and Melvin Schwartz the 1988 Nobel Prize for their development of the neutrino beam method and their demonstration of the doublet structure of the leptons through the discovery of the muon neutrino[11] based on the work at Columbia in the early 1960s.

Mandelstam himself was working on dispersion relations. The purpose of the research was to find a relativistic analogue to the methods developed by Geoffrey Chew, Frances Low and

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[9] Rudolf Peierls to John Cockroft, 10.8.1959, *Peierls Correspondence*, letter 676.

[10] Chretien, M., J. Leitner, N. P. Samios, M. Schwartz, and J. Steinberger. "$\pi^{-}$ p Elastic Scattering at 1.44 Bev." *Physical Review* 108, no. 2 (1957): 383.

[11] Danby, Gaillard, J. M. Gaillard, Konstantin Goulianos, L. M. Lederman, N. Mistry, M. Schwartz, and J. Steinberger. "Observation of high-energy neutrino reactions and the existence of two kinds of neutrinos." *Physical Review Letters* 9, no. 1 (1962): 36.

George and Freda Salzman[12] in order to calculate the pion-nucleon scattering amplitude in terms of two coupling constants only. As the usual dispersion relations by themselves were not sufficient he assumed a representation which exhibited the analytic properties of the scattering amplitude as a function of the energy and the momentum transfer. Requiring unitarity conditions for the two reactions $\pi + N \rightarrow \pi + N$ and $N + \bar{N} \rightarrow 2\pi$ he approximated those by neglecting states with more than two particles.[13] Some years later, Peierls would comment on this work as 'outstanding', describing its effect as so profound that 'it is no exaggeration to say that no paper is being written now on the theory of high energy physics which does not in some way rely on Mandelstam's paper'. Recalling Geoffrey Chew's own assessment of Mandelstam, he reported to John Cockroft, who was trying to entice Mandelstam to take up a position in Cambridge, that the former regarded Mandelstam as the best young man who had been in Berkeley in the time he himself had been there. Given those accolades, it is hardly surprising that Columbia, Birmingham, Cambridge, Berkeley and also Stanford were fighting over Mandelstam in the late 1950s.[14] As we all know, Berkeley would eventually win the day, but for a short period between 1960 and 1963 Mandelstam returned to Birmingham to take up a professorship in Mathematical Physics.

Steven Frautschi, in this volume, relates interesting aspects of the relationship within the research group at Berkeley and also about the workings of Anglo-Saxon research groups more generally – a non-hierarchical collegiality where distinction, if at all existent, was not based on seniority but on scientific standing (which are not at all synonymous). He comments on an encounter of Stanley Mandelstam and Geoffrey Chew and himself with Wolfgang Heisenberg, who mistook Mandelstam's comparatively young age for a student role in the scientific hierarchy. Frautschi's uncompromising denial of Mandelstam's role as a junior figure says a lot about the former's respect of the latter. Of course many physicists – even of the Germanic tradition, would agree that the most inspired contributions often come from exceptional young scholars, anyway. This is possibly best captured in Pauli's infamous statement about physics and age when he first met Viktor Weisskopf and greeted him with:

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[12] Chew, G. F., M. L. Goldberger, F. E. Low, and Yoichiro Nambu. "Relativistic dispersion relation approach to photomeson production." *Physical Review* 106, no. 6 (1957): 1345; Salzman, George, and Freda Salzman. "Solutions of the Static Theory Integral Equations for Pion-Nucleon Scattering in the One-Meson Approximation." *Physical Review* 108, no. 6 (1957): 1619.

[13] Mandelstam, Stanley. "Determination of the pion-nucleon scattering amplitude from dispersion relations and unitarity. General theory." *Physical Review* 112, no. 4 (1958): 1344.

[14] See Gerry Brown to Rudolf Peierls, 8.9.1959, *Peierls Correspondence*, letter 678

‘Ach, so young and already so unknown’.[15] Even though Heisenberg may not have known or recognised Mandelstam in their meeting in the late 1950s, Mandelstam never suffered the fate of being young **and** unknown, because some of his outstanding contributions had indeed already emerged in the early stages of his career.

During Mandelstam’s second stay at Birmingham, now as Professor of Mathematical Physics – a mere six years after completing his PhD - the collaboration with colleagues from Berkeley continued to influence his work, as is evident in his paper on the theory of low-energy pion-pion interaction with Chew[16] and his work on Regge Poles.[17]

In another respect, both Chew’s and Peierls’ influence on Mandelstam could be felt. He was operating firmly within his mentors’ tradition of enthusiastically engaging in teaching and taking pride and joy in bringing the subject to life for his students. Despite his already considerable scientific accomplishments he did so with great humility. This was captured poignantly by one student’s remark that Mandelstam was “the only person I know who does not refer to the Mandelstam Variables by their so-designated name.”[18]

Mandelstam also found time to put pen to paper to write not only for the upper echelons of the physics profession but also for an interested student audience. Not unlike Prof’s ‘Surprises in Theoretical Physics’ more than two decades later, in 1955 Mandelstam and Wolfgang Yourgrau wrote ‘Variational Principles in Dynamic and Quantum Theory’. In this survey, they examined the relationship to dynamic and quantum theory by foregrounding the historical and theoretical developments of the concepts and thereby elucidating the development of quantum mechanics in what a reviewer described as remarkably lucid. This unique combination of intellect and humility, scientific creativity and lucidity proved to be a most powerful toolset accounting for the remarkable achievements while at Birmingham and in the subsequent half century at Berkeley.

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[15] Lederman, Leon M., and Dick Teresi. *The God particle: if the universe is the answer, what is the question?*. Houghton Mifflin Harcourt, 1993, p. 182.

[16] Chew, Geoffrey F., and Stanley Mandelstam. "Theory of the Low-Energy Pion-Pion Interaction." *Physical Review* 119, no. 1 (1960): 467.

[17] Chew, Geoffrey F., Steven C. Frautschi, and Stanley Mandelstam. "Regge Poles in $\pi-\pi$ Scattering." *Physical Review* 126, no. 3 (1962): 1202.

[18] ‘Remembering Stanley Mandelstam, http://physics.berkeley.edu/news-events/news/20160629/remembering-stanley-mandelstam-1928-2016 (accessed 6.10.2016).