

would in particular be interested to see a Soviet account of the information they received concerning that weapon from the confessed spy Klaus Fuchs. In that connection I add two recollections of my own.

I vividly remember a remark made to me by Robert Oppenheimer right after Fuchs had been arrested. He said, more or less verbatim, that he hoped Fuchs had told the Russians all he knew about the "Super" (the hydrogen bomb) since that would set back their efforts by several years.<sup>1</sup>

Next, again about Fuchs: In the spring of 1956 a small group of US physicists (we were 13, I seem to remember) visited the USSR. We were the first postwar invitees to an international physical conference in Moscow. One evening we were entertained for dinner by Kapitsa. The conversation turned to atomic weapons. At some point one of my American colleagues, not known for an excess of tact, remarked that you, the Russians, had it easy because of the information received from Fuchs. Sitting next to Kapitsa I could well observe his reactions. He looked upward, as if trying to remember something, then said: Fuchs? Fuchs? I never heard of Fuchs. Then he turned to Artemii Alikhanian and asked, Have you heard of Fuchs? No, said Alikhanian, he had not heard either. Which goes to show how smartly our host put one of his guests in his place.

## Reference

1. See also C. Norman, *Science* **247**, 151 (1990).

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## Soviet Anti-Semitism in Perestroika's Wake

Just one week after my arrival in the US from Moscow I read in the March issue of *PHYSICS TODAY* (page 52) the pieces by Irwin Goodwin and Vitalii Goldanskii about rising anti-Semitism in the Soviet Union. I share those authors' deep anxiety about the future of Soviet Jews, and I would like to offer several additional, though naturally rather subjective, views on the problem, which is rapidly becoming more aggravated and more dramatic. My comments may be of interest to the physics community because I belong to a younger generation than the most frequent Soviet writers in *PHYSICS TODAY's* pages, and because I held the humble position of a researcher in the USSR Academy of

Sciences, whereas they come from the upper echelons. Thus I can give, so to speak, a view from the bottom.

It is obvious that life is changing in the Soviet Union, and the life of Jews is no exception. I could not have imagined five years ago, for example, that I (being half Russian-half Jewish with a Germanic surname, unmarried, not a party member and having no relatives in America) would be allowed to go to the US as a private person on a private visit.

Nevertheless, I feel that there is no future for Jews in the USSR. Soviet society is awfully ill, and the convalescence may take at least one or two generations. Anti-Semitism is deeply engrained in Russian life. The phenomenon is not confined to the Russian republic; it is widespread throughout the USSR. The totalitarian state actively enforced anti-Semitism in every aspect of life. Partially as a result of this policy, anti-Semitic feelings and intolerance are prevalent among substantial elements of Soviet society, especially in such "responsible" strata as the army, the KGB and the bureaucracy. Just how important and how substantial this part of society is one can judge from the fact that despite numerous appeals (such as the letter of ten scientists and writers to President Gorbachev published in the March *PHYSICS TODAY*), the highest leadership has not condemned this anti-Semitic "peculiar bias" held by probably its most reliable supporters.

Nor is anti-Semitism unknown or unacceptable in the scientific community. Science naturally reflects the state of society. Readers may know that one of the strongest centers of Soviet science is Akademgorodok, near Novosibirsk (the main seat of the Siberian branch of the USSR Academy of Sciences). But they may not know that Akademgorodok is also a notorious center of anti-Semitism, especially active in inflaming feelings that Russia must be "cleansed" and providing "scientific" foundations and support for blaming Jews for problems past and present, existent and nonexistent, from the Bolshevik revolution through drunkenness through *perestroika*.

Even if one day discrimination is prohibited by some decree, not much would change in practice, since life is not governed by the law and a lot is determined by those people "in the field" who previously carried the major burden for preventing Jews from entering educational, scientific and industrial institutions and who are still at their positions in personnel

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and security clearance departments.

It seems to me that the nations constituting the Soviet Union (and the Russians are no exception), which were denied—at first by the Russian Empire, and afterward by the Communists—the right to develop their national cultures, are now eager to go along with national development. Perhaps every nation, before it accepts a more universal view of itself and its neighbors, must go through the phase of being some form of nation-state. And due to the historical realities, Jews will be held as scapegoats and, if not persecuted, then just pushed out by all such nations. It seems that the time is coming for this wandering nation to say farewell to the USSR, as they did in earlier days to Spain, Germany and Poland. For the nations of the Soviet Union, their national problems are, of course, much more important than the relatively marginal problems of the tiny Jewish minority. Such universal values as human destiny, common good, human rights and tolerance were virtually wiped out from the average person by Communist ideology, and society will need a lot of time for painstaking learning. National tensions are rapidly mounting, and unfortunately Russians, the most numerous and leading nation, do not serve as an example of reserve. Fortunately we now live in a “civilized” time, and a new *Endlösung* (“final solution”) is not an immediate threat. I believe the Soviet state will be generous enough to allow an exodus of Jews like the one from Poland in the late 1960s.

A huge “brain drain” seems inevitable if no new “Berlin Wall” is erected. Society will not change drastically, and several generations are needed to develop tolerance. The claim by one of the Soviet scientists quoted in Goodwin’s report that he doesn’t know anybody who wishes to emigrate seems to be relevant mainly to those who are 40–50 years old. I am 35, and potential emigrants are also not very numerous among colleagues of my age, though many would love to go West for a couple of years to work and broaden their horizons. However, the younger generation, those under 30, seems to be different and represents an enormous pool for emigration. More than half a million applications have been submitted for emigration to the US and Israel, and that may be only the beginning of the wave.

After more than 70 years of totalitarian rule almost everybody in the Soviet Union is crippled—morally crippled by Communist ideology and

practice. Jews are doubly crippled due to the additional pressure they receive for being Jewish. Even when Jews have tried to find a refuge in assimilation and surrendered all their national values, language, religion and culture, even when they tried to hide their origins and many even felt shame for being Jewish, they were not accepted as non-Jews by society. They were methodically reminded of who they were. And Jews hired at a “good job” were so grateful for being allowed to work in an important institution that they often were scared to discuss any problems concerning Israel, Jews and so on anywhere but under their own blankets in their own beds. The younger generation has not yet gone through this crippling process, and having had the instructive example of their own parents, many of them will definitely decide to emigrate.

This letter may be considered too emotional, but better to be on the safe side and ring the bell early rather than too late. Who can guarantee that unscrupulous persons of authority will not play the Jewish card in their struggle for power? *Historia est magistra vitae*.

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## The Ancestry of the ‘Anyon’

The interesting news story “Bosons Condense and Fermions ‘Exclude,’ but Anyons . . . ?” by Anil Khurana (November 1989, page 17), though quite detailed in its attributions, actually omitted some significant work on the mathematical and physical foundations for fractional statistics of particles in two dimensions prior to Frank Wilczek’s 1982 articles. In 1980 and 1981 Gerald Goldin (Rutgers) and Ralph Menikoff and David Sharp (Los Alamos) discussed the possibility of such particles using an approach quite different from the 1977 work of Jon M. Leinaas and Jan Myrheim described in the story. Goldin, Menikoff and Sharp derived their result from a mathematically rigorous study of unitary representations of current algebras and groups.<sup>1</sup>

These papers included several of the fundamental facts about “anyons”—the fact that the angle parameter interpolates between Bose and Fermi statistics, the shifted angular momentum and energy spectra, and the connections with the topology of configuration space and with the physics of a charged particle making a

circuit about a solenoid. One consequence of the Goldin–Menikoff–Sharp approach is that it is not necessary to assume a particular configuration space or to exclude “singular” points arbitrarily from the configuration space; rather, the nontrivial topology and fractional statistics emerge naturally from the classification of group representations. In 1983 these authors also identified the braid group as the group whose one-dimensional representations describe the statistics of anyons,<sup>2</sup> and in 1985 they noted (in a comment on a paper by Yong-Shi Wu<sup>3</sup>) that higher-dimensional representations of the braid group could describe important quantum systems in two-space.<sup>4</sup>

This work had its roots in earlier work by Roger Dashen, Sharp, Goldin, Jesse Grodnik and others on local current algebras and groups in quantum theory, growing out of a systematic study beginning in 1968 and spanning more than a decade. In 1975 Mario Rasetti and Tullio Regge (Torino, Italy) proposed to apply these ideas to the quantization of vorticity in superfluids, a program still being actively pursued.<sup>5</sup> A similar perspective on infinite-dimensional Lie algebras and diffeomorphism groups evolved independently from work by Heinz-Dietrich Doebner, Jiri Tolar and others, based on a fundamental reexamination of quantum systems on manifolds.<sup>6</sup>

Like so many deep ideas in physics, the topological underpinnings of anyons can be traced back to Dirac (who in fact originally interpreted the Pauli *Verbot* as a *symmetry* principle). Dirac explained the double covering of the three-dimensional rotation group by means of a string construction,<sup>7</sup> which was in 1942 analyzed by M. H. A. Newman<sup>8</sup> using the braid group—to our knowledge, the first use of the braid group for a physical problem. Though it was recognized at the time that the covering group for two-dimensional rotations has infinitely many sheets (allowing fractional angular momentum), this was considered unphysical. David Finkelstein and Julio Rubinstein in 1968 argued for the topological origin of the exchange phase  $\pm 1$  in three dimensions, noting explicitly that this no longer holds in two dimensions.<sup>9</sup>

These comments are not intended to detract in any way from the important contributions of those mentioned in the story.

## References

1. G. A. Goldin, R. Menikoff, D. H. Sharp, *J. Math. Phys.* **21**, 650 (1980); **22**, 1664 (1981).