CC/NUMBER 30
JULY 28, 1986

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Goldanskii V I. Physical chemistry of positron and positronium.
Atomic Energy Rev. 6:3-148, 1968.
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This is the authorized translation of the monograph *Fizicheskaya khimiya positrona i positroniya*.[1] It describes the use of positron annihilation as a tool for investigating the physical and chemical properties of matter and contains a general introduction to the subject, achieved results, and promising prospects—based to a large extent on my own research. The main task was to call broad attention to extremely wide possibilities of applications of positron annihilation in chemistry and in material studies. [The *SCI*® indicates that this paper has been cited in over 170 publications, making it the most-cited paper for this journal.]

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June 13, 1986

Following my postgraduate years at the Institute of Chemical Physics of the Academy of Sciences of the USSR under the supervision of academician N.N. Semenov, I was involved for a decade in nuclear and high-energy physics. By the end of the 1950s I longed to go back to chemical physics and to apply to this field all the accumulated experience, ideas, concepts, and techniques of nuclear and elementary particle physics.

While studying positron annihilation in gases, M. Deutsch had discovered the lightest hydrogen-like atom—positronium (Ps)—consisting of electron and positron, i.e., the only atom in the universe without a heavy nucleus.[2] Soon afterward, R. Bell and R.L. Graham demonstrated that the formation of positronium atoms might precede the positron annihilation in condensed phases too.[3]

Initially, my interest in chemical applications of positron annihilation sprang from the idea that positronium as a free atom might possess a high chemical reactivity. Furthermore, being a thousand times lighter than the hydrogen atom, positronium should display a much more pronounced capability for tunneling penetration through potential barriers. Indeed, a comparison of the positronium vs. hydrogen chemical reaction rates[4] seemed to encourage the study of tunneling phenomena in chemical kinetics, which enthralled me for more than a quarter of a century (see reviews[5,6]).

I would have hardly made up my mind to write a monograph on this subject if it were not for Len Roellig and Alec Stewart, who had organized the First International Conference on Positron Annihilation at Wayne State University in July 1965. My invited talk[7] laid the groundwork for the monograph, which deals with three types of positron annihilation: (1) in free collisions with electrons, (2) in positronium atoms, and (3) in compounds formed by positrons with atoms and molecules. The physical and chemical information yielded by each of these annihilation mechanisms was analyzed.

The monograph examines the basic experimental methods of observing positron annihilation. Data on inhibition of positronium formation were surveyed, and possibilities for their use as a source of information on the mechanisms of electron slowing, ionization, and excitation of molecules were considered. Experiments on positronium quenching were described and lines of research were suggested in which quenching could be used to investigate the kinetics of the reactions of hydrogen-like atoms in gases and condensed materials. The main results of research on electron momentum distribution using measurements of the angular correlation of annihilation gamma-rays were also described.

During the 18 years since this monograph was written, interest in the problems presented there has increased dramatically. The number of new papers published annually on this theme is now substantial. Large international conferences on positron annihilation became traditional; the seventh such conference was held in January 1985 in New Delhi, India.

Among various streams in the positron studies, especially widespread is the positron defectoscopy of various solids. Disclosure of its rich possibilities was started by my joint theoretical paper with Ye.P. Prokopyev.[8] A detailed survey of further studies of this problem was published by A. Dupasquier.[9]

In 1977 the Academy of Sciences of the USSR awarded V.P. Shantarovich and me the V.G. Khlopin prize for the series of papers on positronium chemistry.

I feel particularly satisfied by the fact that our laboratory in the Institute of Chemical Physics of the Academy of Sciences of the USSR and my monograph have attracted to positronics a number of scientists, who were at that time still quite young and are now acknowledged experts in this field and leaders of research groups in the USSR and elsewhere.

1. **Goldanskii V I.** *Fizicheskaya khimiya positrona i positroniya.* Moscow: Nauka, 1968. 174 p.
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5. **Goldanskii V I.** Facts and hypotheses of molecular chemical tunneling. *Nature* 279:109-15, 1979.
6. **Goldanskii V I, Fleurov V N & Trakhtenberg L I.** Modern concepts of the tunneling of heavy particles in chemical conversions. *Sov. Sci. Rev.—Ser. C—Chem.* 9, 1986. (In press.)
7. **Goldanskii V I.** The quenching of positronium and the inhibition of its formation: role of phase transitions, magnetic and chemical factors. (Roellig L O & Stewart A T, eds.) *Positron annihilation.* New York: Academic Press, 1967. p. 183-255. (Cited 45 times.)
8. **Goldanskii V I & Prokop'ev E P.** Annihilation of positrons in alkali-halide crystals. *Sov. Phys.—Solid State* 6:2641-4, 1965. (Translated from *Fiz. Tverd. Tela SSSR* 6:3301-6, 1964.)
9. **Dupasquier A.** Positrons in ionic solids. (Hautojärvi P, ed.) *Positrons in solids.* Berlin: Springer, 1979. p. 197-243.

2 A4