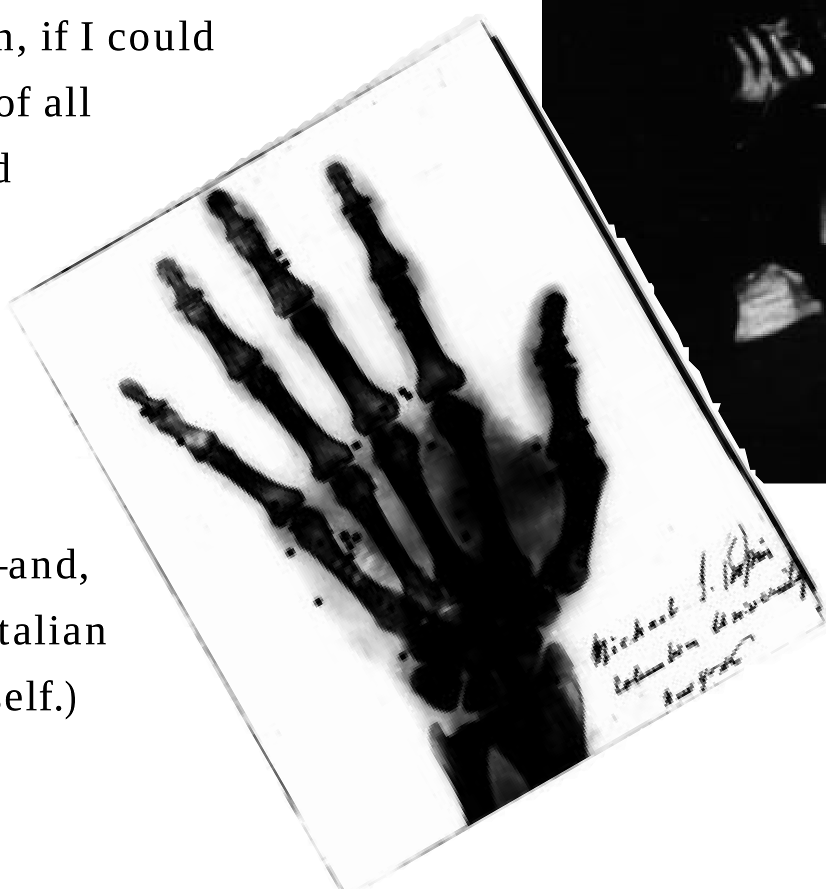
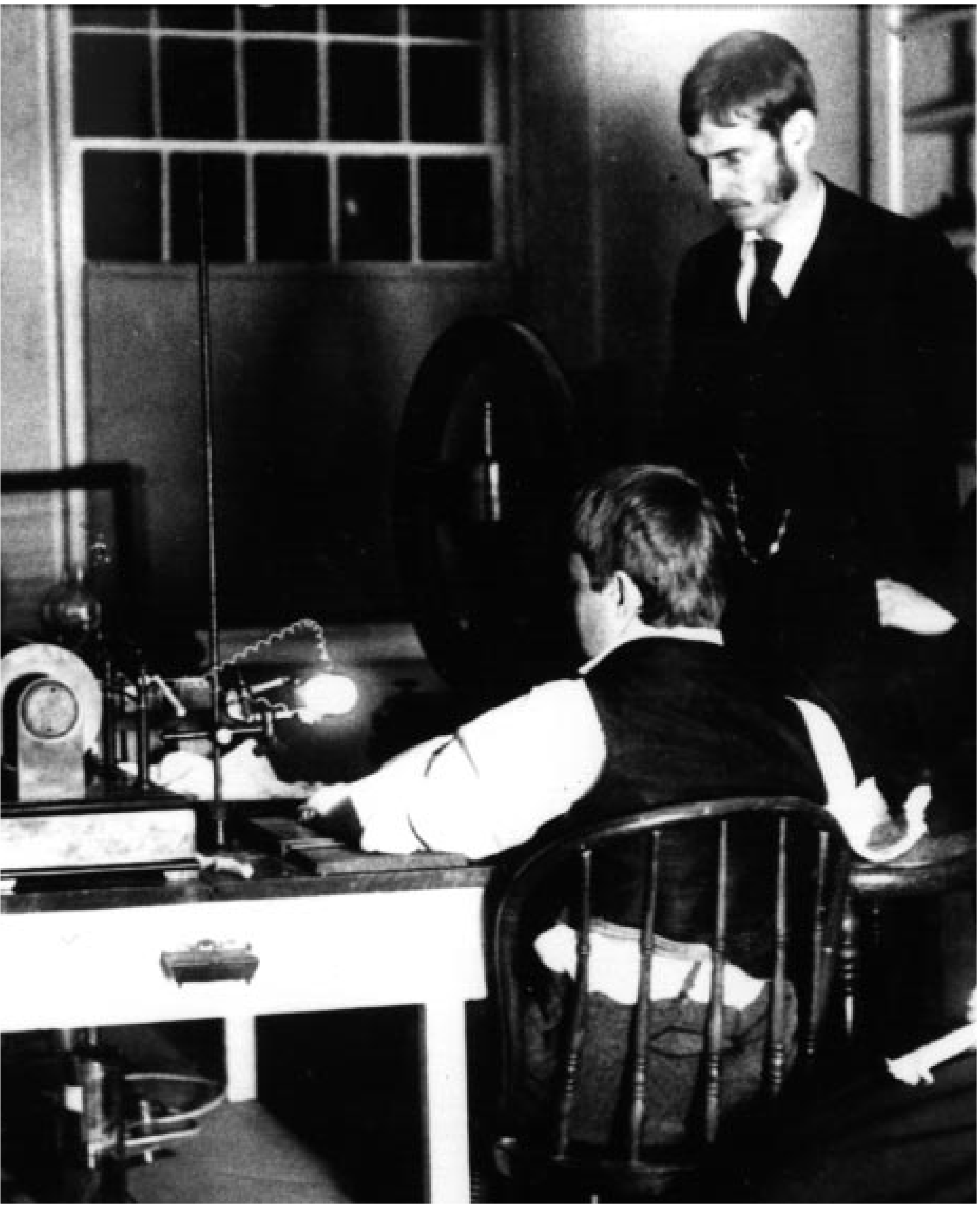
How the Twentieth Century Started Ahead of Time

The Centennial Encounter of a Physicist

by PHILIP MORRISON



ENRICO FERMI is said to have evaded some query about a new particle with this rebuff: "Young man, if I could remember the names of all those particles I would have become a botanist." (It is true that the first really new particle, the neutrino, was first understood—and, in fact, was given its Italian name—by Fermi himself.)



The New-York Times.

Wednesday

February 5-1896

PROF. ROENTGEN'S X-RAYS

May Be Due, He Says, to Longitudinal Vibrations of Ether.

HE WRITES OF HIS GREAT DISCOVERY

Difference Between His and the Kathode Rays of Lenard—Some of the Substances He Has Photographed.

The preliminary communication of Prof. Wilhelm Konrad Röntgen to the Würzberg Physico-Medical Society of his discovery of a new form of radiant energy appears this week translated in full in several of the English papers. As the chief interest of men of science is centred in the question of the nature of the rays, these portions of Prof. Röntgen's paper which deal with this aspect of the subject are here reproduced in full.

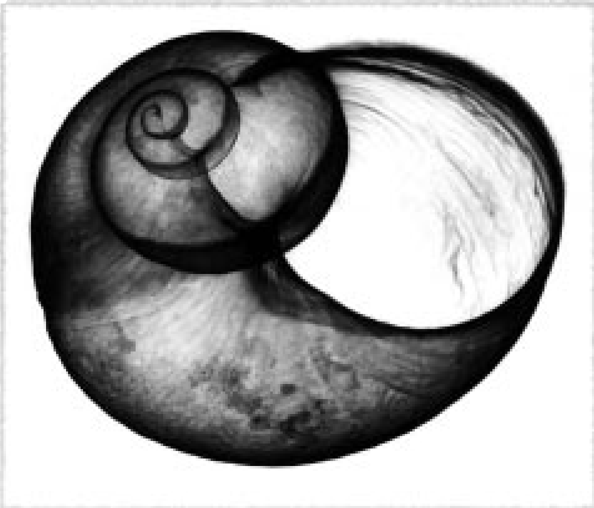
The name given by Prof. Röntgen to the newly discovered form of radiant energy is X-rays. The translation appended was made by Arthur Stanton, and appears in the current number of Nature. After describing his experiments in making shadow photographs of various substances, Prof. Röntgen says:

7. After my experiments on the transparency of increasing thicknesses of different media, I proceeded to investigate whether the X-rays could be deflected by a prism. Investigations with water and carbon bisulphide in mica prisms of 30° showed no deviation either on the photographic or the fluorescent plate. For comparison, light rays were allowed to fall on the prism as the apparatus was set up for the experiment. They were deviated 10 mm. and 20 mm. respectively in the case of the two prisms.

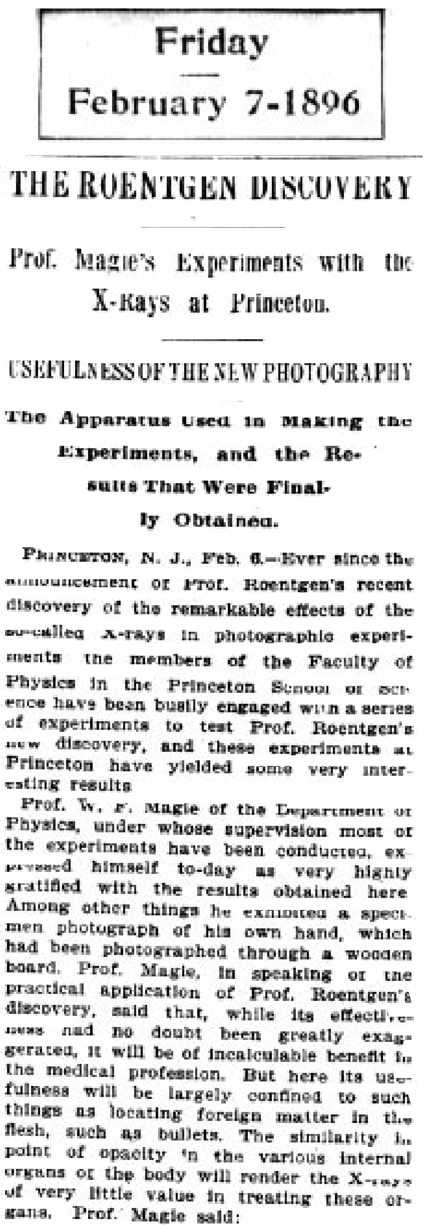
With prisms of ebonite and aluminium I have obtained images on the photographic plate which point to a possible deviation. It is, however, uncertain, and at most would point to a refractive index 1.05. No deviation can be observed by means of the fluorescent screen. Investigations with the heavier metals have not as yet led to any result, because of their small transparency and the consequent enfeebling of the transmitted rays.

On account of the importance of the question it is desirable to try in other ways whether the X-rays are susceptible of refraction. Finely powdered bodies allow in thick layers but little of the incident light to pass through, in consequence of refraction and reflection. In the case of the X-rays, however, such layers of powder are for equal masses of substance equally transparent with the coherent solid itself. Hence we cannot conclude any regular reflection or refraction of the X-rays. The research was conducted by the aid of finely powdered rock salt, fine electrolytic silver powder, and zinc dust already many times employed in chemical work. In all these cases the result, whether by the fluorescent screen or the photographic method, indicated no difference in transparency between the powder and the coherent solid.

It is, hence, obvious that lenses cannot be looked upon as capable of concentrating the X-rays; in effect, both an ebonite and a glass lens of large size prove to be without action. The shadow photograph of a round rod is darker in the middle than at the edge; the image of a



X-ray photograph of a snail shell taken by SLAC *physicist Hobey DeStaebler at the Stanford Physics Department in 1962 (×2.4).*



Friday
February 7-1896

THE ROENTGEN DISCOVERY

Prof. Magie's Experiments with the X-Rays at Princeton.

USEFULNESS OF THE NEW PHOTOGRAPHY

The Apparatus Used in Making the Experiments, and the Results That Were Finally Obtained.

PRINCETON, N. J., Feb. 6.—Ever since the announcement of Prof. Roentgen's recent discovery of the remarkable effects of the so-called X-rays in photographic experiments the members of the Faculty of Physics in the Princeton School of Science have been busily engaged with a series of experiments to test Prof. Roentgen's new discovery, and these experiments at Princeton have yielded some very interesting results.

Prof. W. F. Magie of the Department of Physics, under whose supervision most of the experiments have been conducted, expressed himself to-day as very highly gratified with the results obtained here. Among other things he exhibited a specimen photograph of his own hand, which had been photographed through a wooden board. Prof. Magie, in speaking of the practical application of Prof. Roentgen's discovery, said that, while its effectiveness had no doubt been greatly exaggerated, it will be of incalculable benefit to the medical profession. But here its usefulness will be largely confined to such things as locating foreign matter in the flesh, such as bullets. The similarity in point of opacity in the various internal organs of the body will render the X-rays of very little value in treating these organs. Prof. Magie said:

If I could have recalled dates well, I might have become a historian! Many physicists share my inner need for such approximation, and so it is not really remarkable that twentieth-century physics itself began a few years early, on New Year's Day of 1896. On that day Professor Wilhelm Roentgen mailed from his university at Würzberg the preprints of his forty-ninth paper. (His first forty-eight are less well known.) He included an X-ray photo of his own hand, a piece of bone-hard evidence for the new penetrating radiation. So much the books tell us.

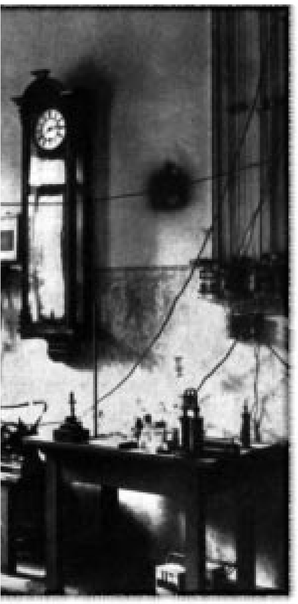
My own encounter with the dawn of twentieth century physics was personal, but of course second-hand. Even so veteran a member of the APS as myself doesn't go all the way back to Gibbs and Helmholtz. But the anecdote makes vivid connection with Roentgen on this present occasion, the hundredth anniversary of his recognition of X rays.

The story unfolds in an unexpected location in space-time, Oklahoma City, Oklahoma, about 1976.

I found myself in Oklahoma through the formidable persuasive powers of Jerrold Zacharias, physicist and impresario at MIT. Zach had already drawn me to MIT years before. He was so energetic and effective as an organizer and standard-setter for science education at every level that he was then a very fountain of opportunity to do good for physics students anywhere. This time it was the Oklahoma City University that would provide me an audience for a rousing popular talk on something new in physics. I cannot really recall my topic; pretty surely it was about quasars or supernovae or the microwave background, something out of current astrophysics, presented for the interested but unspecialized student of physics.

The details were elided by Zach; we always worked on mutual trust. There would be an evening public lecture on the Oklahoma City campus to which I had acceded cheerfully long before. But a luncheon meeting earlier in that day was my first encounter with my hosts. It was marked by experiences unique in all my years of such little formalities.

The luncheon setting was not at all novel; a lot of people sat at table in some club or hotel dining room, whom I faced from my place at a long table among a dozen or so who were singled out for introduction. What was novel was my luncheon partner, who was sitting beside me. He was a spry and articulate elder, and I soon learned that this day was—at least for official purposes—his own hundredth birthday. Not only was he a man of unrivaled seniority, but he was the focus of the whole event, my



The interior of Roentgen's laboratory at Würzburg.

X-ray photograph of two spring-blooming daffodils taken by Hobey DeStaebler (×0.5).

lecture and all. A pillar of Oklahoma City life, he was a generous benefactor to the City University, and the owner, if I remember well, both of the city's main newspaper and of its chief TV station. Plainly he was ruler on this day of all days.

I was there, a visitor from MIT, to speak about physics on campus at his express request for a good lecture. He had very sound reason; the now-powerful centenarian had been a physics student while an undergraduate, and he still loved and admired the subject. He had drifted away into a long career in journalism to reach an elevated level of achievement, but he still wanted to talk physics when he could. At some point I came to ask him about his days as a student of physics so long ago, and he unfolded this wonderful narrative.

He was then a student at Colorado College in Colorado Springs. One morning in January 1896 he came to the physics lecture room as usual. But the lecturer was filled with uncommon excitement. (Here I can only paraphrase what I recall from my hundred-year-old companion .)

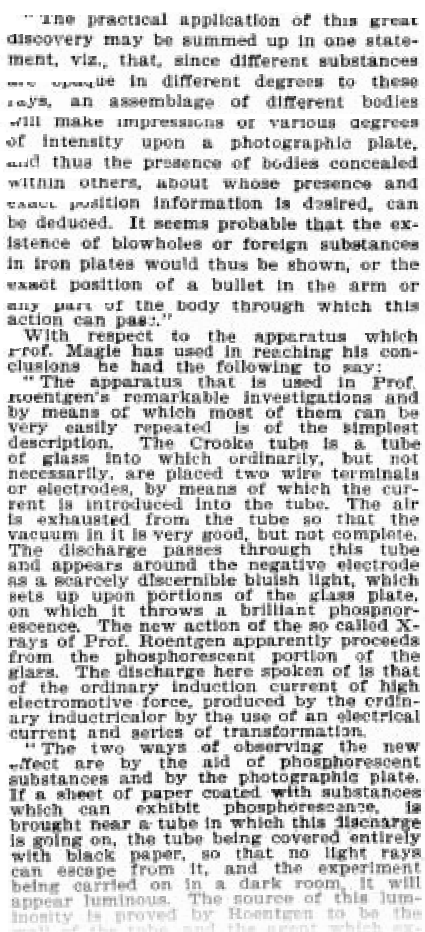
"Gentlemen," began the lecturer, "something so unusual has happened that I want to seek your help. If you consent, we will not simply go ahead with the planned lecture. Instead we will all work together in the lab to an amazing new purpose.

"This morning's newspaper brought a report that a German professor has discovered an extraordinary new form of radiation, one so penetrating that for instance he is able to photograph the bones within the living hand, or a coin hidden inside the pages of a thick book. The story is not very complete, but it says enough about how it was done that I think we could duplicate the results with apparatus we have right here in our college laboratory.

"It would be wonderful to do that, and perhaps we might even be the first in all America to repeat his result, since we are getting started in the first hours of the morning. Let's get going; first we'll collect what we need and then set it up.

"If we all work together we can easily do the job by lunchtime. Will you join me?"

The delighted class set about the task. The needed materials were all soon found on the lab shelves: the big sparky induction coil, the Crookes tube, the fluorescent screens, the darkroom materials, the filters of black paper....Soon it all came together. And it worked! By lunchtime my host recalled running over

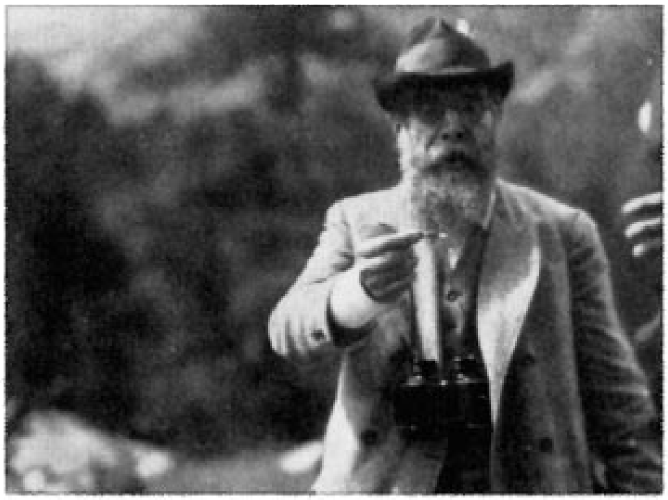


"The practical application of this great discovery may be summed up in one statement, viz., that, since different substances are opaque in different degrees to these rays, an assemblage of different bodies will make impressions of various degrees of intensity upon a photographic plate, and thus the presence of bodies concealed within others, about whose presence and exact position information is desired, can be deduced. It seems probable that the existence of blowholes or foreign substances in iron plates would thus be shown, or the exact position of a bullet in the arm or any part of the body through which this action can pass."

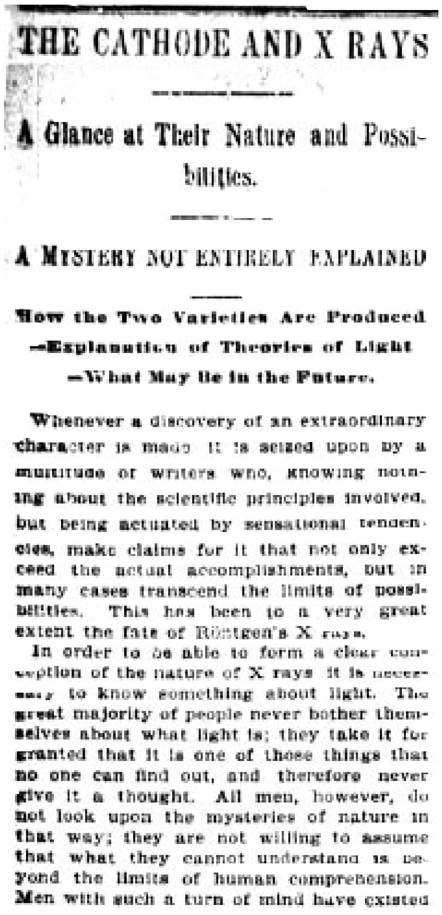
With respect to the apparatus which Prof. Magie has used in reaching his conclusions he had the following to say:

"The apparatus that is used in Prof. Roentgen's remarkable investigations and by means of which most of them can be very easily repeated is of the simplest description. The Crooke tube is a tube of glass into which ordinarily, but not necessarily, are placed two wire terminals or electrodes, by means of which the current is introduced into the tube. The air is exhausted from the tube so that the vacuum in it is very good, but not complete. The discharge passes through this tube and appears around the negative electrode as a scarcely discernible bluish light, which sets up upon portions of the glass plate, on which it throws a brilliant phosphorescence. The new action of the so called X-rays of Prof. Roentgen apparently proceeds from the phosphorescent portion of the glass. The discharge here spoken of is that of the ordinary induction current of high electromotive force, produced by the ordinary inductricalor by the use of an electrical current and series of transformation.

"The two ways of observing the new effect are by the aid of phosphorescent substances and by the photographic plate. If a sheet of paper coated with substances which can exhibit phosphorescence, is brought near a tube in which this discharge is going on, the tube being covered entirely with black paper, so that no light rays can escape from it, and the experiment being carried on in a dark room, it will appear luminous. The source of this luminosity is proved by Roentgen to be the wall of the tube, and the agent which ex-



Roentgen out walking later in life.



THE CATHODE AND X RAYS

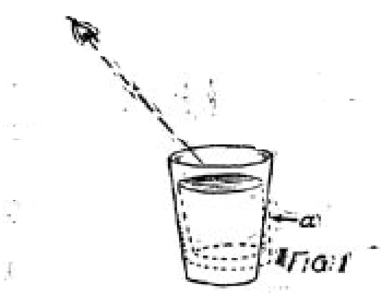
A Glance at Their Nature and Possibilities.

A MYSTERY NOT ENTIRELY EXPLAINED

How the Two Varieties Are Produced—Explanation of Theories of Light—What May Be in the Future.

Whenever a discovery of an extraordinary character is made it is seized upon by a multitude of writers who, knowing nothing about the scientific principles involved, but being actuated by sensational tendencies, make claims for it that not only exceed the actual accomplishments, but in many cases transcend the limits of possibilities. This has been to a very great extent the fate of Röntgen's X rays.

In order to be able to form a clear conception of the nature of X rays it is necessary to know something about light. The great majority of people never bother themselves about what light is; they take it for granted that it is one of those things that no one can find out, and therefore never give it a thought. All men, however, do not look upon the mysteries of nature in that way; they are not willing to assume that what they cannot understand is beyond the limits of human comprehension. Men with such a turn of mind have existed



to the Colorado College chapel to borrow a large Bible in whose pages they could hide a silver coin. The excitement was unforgettable.

Of course they were not to be the first in America to run the experiment. For the morning papers had carried the story very widely. Colorado had an irremediable handicap: its longitude. So far west, they were late in starting, behind the many physics labs of the Eastern time zone a couple of hours as the earth turns. Many had had a similar idea, and some of the Easterners would surely be first. I have no real data on exact times or even dates, but I do know that Penn, Princeton, Columbia, Cornell, Harvard, Dartmouth, and others recall very prompt repetitions of Roentgen's wonderful result.

This result came as though a seed crystal had been dropped into a saturated solution! The new physics crystallized out everywhere at once; the requisite apparatus was already there in all serious labs around the world. On the 20th of January, Henri Poincaré, who had received a New Year preprint from Roentgen himself, showed the marvelous photos to the session of the Paris Academy. Henri Becquerel was there, an expert on fluorescence like his father before him, and by March 2 Becquerel had found, largely by happy accident, that a uranium compound emitted some such active radiation spontaneously, without requiring exposure to light or any other energizing input. Radioactivity had been discovered, and the physics of the twentieth century had begun, for good and for ill.

What a story! Yet it was to be capped that very evening. Of course I could not fail to re-tell the physics student's birthday story as a preface to my lecture. It went well, although certainly it was a digression. After my talk, a young man came up to speak to me. He was no undergraduate; he introduced himself as a physics postdoc at work for a year or two in Oklahoma. His home was Germany, where he had taken his doctor's degree. What he told me was a family story that he had first heard in his childhood, often told and retold in his presence. It was his elderly uncle, a physician, who was the storyteller.

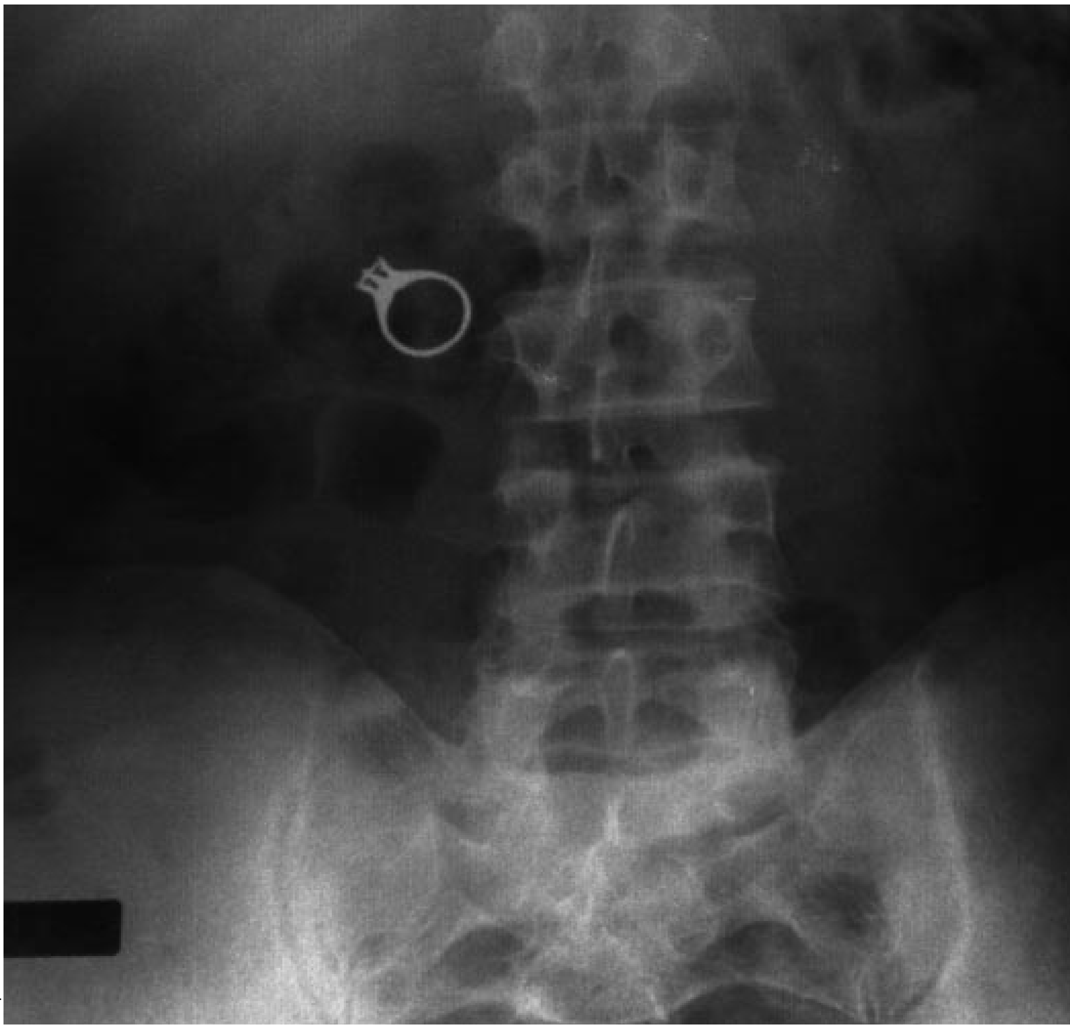
That man had been a medical student in Würzberg in 1896. He took physics from Roentgen. One day the Professor told his physics class of his recent work and demonstrated it briefly. Now, it is an ancient custom in the German universities for students to indicate high pleasure and approval by remaining seated in place while beating their shoes smartly on the floor. In the usual lecture theater there the seats rise up in rows step after step, to allow all to view the lecture table. The floor structure is thus hollow and resonant, and the noise of the footbeats is grand. The students that day approved mightily of Roentgen's miracle, and continued their racket, so Uncle reported, for *one full hour* without stopping. Twentieth-century physics was made welcome for the first time.

It is curious that the best-known finding of twentieth century physics was made in the same well-seeded context on the brink of WWII in January 1939. The celebrated Berlin experimenter Lise Meitner, newly exiled in Sweden, spent Christmas Day in a park near Stockholm with a visitor from Copenhagen, her younger nephew, physicist Robert Frisch. The two talked over the amazing new report from Meitner's old lab that demonstrated that uranium upon irradiation by neutrons yielded radioactive products that included not only the expected elements close to uranium in atomic weight, but one that was only about half as heavy. At one point in the conversation they both came to an explanation and soon mutually understood that uranium had fissioned into two heavy fragments, and that the fragments must fly apart with unprecedented energy, to be detectable by the heavily ionized tracks they left in matter. Within two weeks Frisch had seen on the oscilloscope screen the unmistakable strong spikes of ionization they had expected.

Their news came out even before publication, by word of mouth direct from Niels Bohr, who had sailed off to a conference in Washington held in the last week of January. Within days eager phone calls back to home labs by the physicists who had heard Bohr had induced the production of those very spikes in many places (I saw them myself then at Berkeley); within weeks they were certainly familiar all over the world. You had mainly to scrounge a small amount of uranium compound in the chemistry storeroom. The fission spikes were easy to find with the little ion chambers, oscilloscopes of modest gain, and weak neutron sources that every serious nuclear physics lab then held, as forty-three years before every lab working with electrical discharges through gases already had its Crookes vacuum tube and high voltage source on the shelf.

History had repeated itself. The first time the stunning discovery was rather light-hearted, in those shadow photos through closed books and bony hands, but the second time it was fateful. By the spring of 1940 six governments, all of them already at or close to war, had each formed its own initial organization to seek large-scale energy from uranium.

For the last few years we have come to share reason for hope that the hundredth anniversary of fission, when it arrives, will indeed be commemorated mainly among the physicists, and not everywhere to universal public dismay instead of prolonged applause.



AP photo

This X ray image, taken in North Providence, Rhode Island, Thursday, Feb. 16, 1995, shows a diamond ring that was swallowed by a robber to fool police.