University of Manchester "Centenary of Transmutation" One-Day Meeting

Saturday, June 8, 2019

Partial Meeting Transcript — by Steven B. Krivit

Link to News Story and Video Clips
Link to Campbell Discussion Analysis

VIDEO #1
Peter Rowlands: Welcome, ladies and gentlemen, to this celebration of the centenary of transmutation, which took place in this very department 100 years ago.

VIDEO #2
Sean Freeman: We're here today to mark 100 years since the publication of a series of four papers by Ernest Rutherford, who was then the Langworthy Chair at the Victoria University of Manchester.

We've got a very interesting program of expert speakers. I'm not an expert on the historical subject matter of today, but by way of introduction, I want to set the scene and make a few comments as a current jobbing nuclear physicist. Rutherford moved to Manchester in 1907 after performing work on radioactivity in McGill University in Canada that won him the Nobel Prize in chemistry. It probably attests to Rutherford's genius that, arguably, his most famous work was done after the Nobel Prize and done here at Manchester.

Between 1907 and the start of the First World War, he achieved a number of important results that defined the start of the field of nuclear physics. He had sorted out the structure of the atom; he discovered the atomic nucleus with his interpretation of the famous Geiger-Marsden gold foil scattering experiments. That finding, along with football, cotton mills, and Boddington's beer, is still infused in marketing the city of Manchester today. I should add that other Manchester beers are available. He proved that alpha radiation is composed of helium nuclei and was guided by the first ionization chambers to measure radiation. But the work we will discuss today is essentially the first initiation observation of a nuclear reaction.

The work was done during World War I under rather difficult conditions. Rutherford did what he could in between war work. It followed on from some initial measurements made by Marsden, who found intriguing results, that swift hydrogen nuclei were observed when investigating the passage of alpha particles through gases. Rutherford's work proved categorically that these particles were indeed protons. He found that their incidence dramatically increased with the introduction of nitrogen gas into the apparatus — many more than could be explained by protons being knocked on from any hydrogen-containing material in the apparatus. He very carefully and painstakingly eliminated all the possibilities other than it was the alpha particles interacting with the nitrogen nuclei that produced protons by a nuclear reaction.

Later experiments showed that what was true with nitrogen was also true for other gasses and metal foils. He saw protons liberated from nuclear reactions on many different targets. This was really the discovery that protons were a universal constituent of all atomic nuclei, fundamental constituents of atoms. Rutherford remained actually a little bit bothered. He couldn't quite believe himself over paranoid anxiety that the apparatus wasn't completely free of hydrogen and that protons were just being knocked forward from some unrevealed hydrogenous material. In 1921, he did careful experiments with James Chadwick in Cambridge that showed that protons knocked on from hydrogen gas were demonstrably less energetic than those liberated from reactions on nitrogen.

Later, painstakingly research done by Patrick Blackett, at Rutherford's suggestion, began in Cambridge and were published in 1924. [Blackett] successfully used a cloud chamber to find visible tracks of the disintegration that Rutherford had discovered in Manchester. And in a sense, Blackett became the first person to reveal the details of the process: an alpha particle fusing with a hydrogen nucleus to form an excited fluorine sister, which then ejects a proton, leaving a residual nucleus of oxygen.

VIDEO # 6
14:40
John Campbell: Rutherford kept seeing these hydrogen nuclei recoiling at greater distances than the alpha could possibly get. He found all sorts of things, but in particular he noticed that, when he changed his gases in this container and put in nitrogen, he saw a heck of a lot of these things at greater distances than the alphas could possibly do it. He wrote his papers up involving the collisions with alphas with oxygen, nitrogen, and hydrogen. He held over till after the war. At the time, he had been transferred to the Cambridge lab to take over from J.J. Thomson. He was retiring to become the Master of Trinity. So the father of the electron handed over the chair to the father of the nucleus. These four papers came out at this time of year in 1919. Scientifically, Rutherford received quite a bit of kudos. The number of honorees, doctorates and things really spiked just after this. It didn't create a great deal of interest in the public domain; it was a bit esoteric.

16:22
[Campbell talks about the Nordmann article in *Le Matin*, syndicated stories via wire services in the U.S. the same day.]

17:30
[Campbell talks about the 1902-3 work that Rutherford performed with Soddy. He talks about a claim from 1783 by James Price of making gold from mercury.]

19:17
[Campbell talks about Sir William Ramsay's claim of transmutation.]

21:45
[Campbell begins talking about New Zealand’s stamp featuring Rutherford.]

23:34
John Campbell: A lot more detail is in there, my book and the DVD, the three-volume DVD, although the detail about this side of it, I found out much more about since I wrote my book. I just assumed that the people writing about Rutherford, who knew him, were right, but then I've found out they never looked at the article — I assumed — records of the day, and just formed their own guesswork.

24:15
Peter Rowlands: Questions or comments? Oh, sorry — Neil.

DISCUSSION #1
24:26
Audience member (possibly Neil Todd): Thanks for a nice talk. I will take you back to your reference to Rutherford showing that the recoil range of oxygen and nitrogen were anomalously the same. [Inaudible] as you remember, in the discussion of Part IV, he wrote this again and draws our attention to the result he first noticed in Part III. There's one sentence where he actually brings it — this anomalous recoil energy of the swift nitrogen. He says if that's associated with the production of hydrogen atoms, then this might explain the anomalous energy. Now he's not actually saying that the anomalous nitrogen is oxygen, but it appears to me that he has identified pretty accurately that the energy of the recoil atom is the same as oxygen —

[Campbell interrupts]

25:40
John Campbell: He stated unequivocally in his Paper 4 that the hydrogen nucleus had come out of the nitrogen nucleus, and therefore it was a component part of the nitrogen nucleus. He had split the atom and transmutation and all that and produced hydrogen. But from the other three papers, he talks about the range, and they're about the same. You could say that he was on the ball. But he never claimed it was oxygen.

26:21
Audience member: No, he never claimed that, but in that section in Part IV, it's almost as if he's putting out an alternative to the disintegration. He's saying that the recoil atom, the swift nitrogen, has the energy of oxygen.
26:40
John Campbell: The recoil was in Part IV [inaudible] oxygen and nitrogen.

26:21
Audience member: We will discuss it later.

DISCUSSION #2
26:57
Audience member: [inaudible] what he thought happened to the alpha particle during that experiment.

27:06
John Campbell: He made the statement that, in doing this — you see a lot of these were the alpha particles just bouncing off the hydrogen — hydrogen scattering and so on. He said the surprising thing is that the alpha particle stayed whole, it wasn't broken up. He could see that, if they could generate high-energy alpha particles, they could break up [inaudible].

27:42
Audience member: I was wondering when, following [inaudible] experiments, he either wrote or decided that the alpha particle was actually being incorporated into the nitrogen, as it were.

22:56
John Campbell: When he was firing at the nitrogen and a hydrogen nucleus came out, it had to have been part of it. He couldn't tell nitrogen from oxygen. So it didn't matter whether it was nitrogen or oxygen. But he never made any comment about that. He was just adamant that a nitrogen nucleus contained a proton. He was amazed that the alpha particle hadn't been split up in doing these experiments. It always just stayed the same, being ejected, except in this case.

28:43
Audience member: Did he ever at any time prior to Blackett's experiment consider that oxygen could be [a product of the] reaction? Did he wait until Blackett's experiment before he came up with this idea?

29:00
John Campbell: That was the confirmation, but in 1921, Rutherford got [Shimizu] to build an automated cloud chamber to examine this. Then he returned to Japan, and the project was handed on to Blackett. [Blackett] found through the cloud chamber that it was definitely oxygen that was produced. But no, he never made any claim that oxygen was being produced. All he'd done was produce hydrogen.

DISCUSSION #3
29:37
Audience member: The obvious thing that he says in this paper, which I just happen to have it in front of me, is that the hydrogen atom which is liberated formed a constituent part of the nitrogen nucleus. So you could say he imagined the alpha particle chipped a proton. But that, of course, would have made carbon. Did he ever speculate that he made carbon?

30:00
John Campbell: Not that I'm aware of. With all this alchemy, gold from mercury and all that [inaudible] while he worked on it [inaudible].

DISCUSSION #4
30:25
Audience member: It might be worth mentioning of course that Rutherford was an incredibly thorough guy, but he was pretty sure that disintegration was occurring, back in 1917. There was a quote that I'm sure you're familiar with: He turned up late after a committee —

30:44
John Campbell: Oh, yeah, about submarines.

30:47
Audience member: — about war. He apologized and said, 'I'm sorry, gentlemen, that I'm late for the meeting, but it might be possible to artificially disintegrate an atom, and if that's true, it's far more important than the war.'

31:00
John Campbell: [Inaudible]

DISCUSSION #5
31:15
Audience member: I was going to come back to the discussion you had with Peter. I agree that, in the discussion part of Part IV, the explanation appears in that sentence I quoted about the anomalous recoil energy of the swift nitrogen atom, as he calls it, having the equivalent to oxygen. It's almost as if he's putting out an alternative to the disintegration idea. But the concept of disintegration continued over even to Blackett. Blackett's 1925 paper was called "The Ejection of Protons from Nitrogen Nuclei."

32:00
John Campbell: No, to me, it was all over in 1919, 1920. In 1920, at the Bakerian lecture, Rutherford suggests that there had to be a neutral particle of the same mass as the proton. If you count the isotopes — in that same talk, he started building up atoms from protons — there is hydrogen, then helium with two protons and two neutrons, and so on up. He started to prove out [inaudible], but a lot of the bits and pieces were known to explain isotopes at that time. It took, from when he predicted in 1920, 12 years before a neutron was discovered. Chadwick kicked himself because he knew about Rutherford's prediction [inaudible] talk about all sorts of things [inaudible] neutron, it's uncharged, it would be very hard to detect. Chadwick had picked up on that. [Inaudible]

Discussion #6
33:26
Audience member: If there is a fusion of the alpha particle to the nitrogen nucleus and a proton comes out, you get oxygen 17. Is there a —

32:36
John Campbell: Yes.

[Both speaking simultaneously.]

33:44
Audience member: Is there any way of detecting by a magnetic field if that is normal oxygen? Could you detect that it was oxygen-17?

33:56
John Campbell: No, these were just individual particles, and for [inaudible], you need billions of particles. That's why it had to be by imaging [inaudible].

Discussion #7
34:13
Audience member: Can I ask you another question based on what he says in the paper? He says, "The results as a whole suggest that, if alpha particles — or similar projectiles — of still greater energy were available for experiment, we might expect to break down the nucleus structure of many of the lighter atoms." Was he then thinking about going to Cambridge and building accelerators?

34:45
John Campbell: That's the bit that I had to cut out of the talk [inaudible] the basis of what started in Canada. [Inaudible]

34:55
Audience member: Do think he was thinking about accelerators?

[Discussion about accelerators, alpha emitters, half-lives, Geiger, Gamow, and Cockcroft.]

42:55
[End]