THE ELECTRON RING ACCELERATOR*

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ABSTRACT

The principles of the electron ring accelerator will be presented; along with characteristic parameters. The present status of understanding will be reviewed, with attention to the diverse phenomenon which control -- and circumscribe -- the accelerator performance. The LRL model program will be described.

NOTE: This paper was submitted to the conference only for oral presentation and the reader is referred to the Proceedings of a recent symposium.

Symposium on Electron Ring Accelerators
Lawrence Radiation Laboratory (UCRL 18103, Feb. 1968)
UC 28 Particle Accelerators and High Voltage Machines
TID 4500 (51st Ed.) Clearinghouse for Federal Scientific and Technical Information, NBS, Springfield, Va.

The following discussion was considered to be of sufficient interest to justify publication.

DISCUSSION

SCHOPPER, KARLSRUHE: I should like to ask a question with respect to the calculations of radiation loss. If I understood Lawson right he thinks that his result is not in disagreement with the Russian calculations but rather that these are two extreme cases. The Russian result is valid for small γ whereas Lawson's computations are valid for large γ. Hence, both results might be right which would imply a severe restriction on the maximum energy obtainable. I wonder if you could comment on this.

SESSLER, LRL: I think I have said what I know about the radiation problem. I think you are correct in that he believes his formula should be added to the Russian formula. The Russian formula involves wavelengths with a cut-off of the order R and Lawson's formula covers wavelengths from the order R to R/γ. His formula is for a higher frequency range. I don't know whether his formula is right or not.

REES, MIT: How did the Russians measure the number of protons that they actually captured in the electron ring?

SESSLER, LRL: All we know is that they had a valve through which they let in gas and there was a wide range of pressure over which they were successful. I am afraid none of us know the details.

COURANT, BNL: At the beginning of your talk you spoke of a new model of compressor and extractor made up of two solenoids. Will this create a lot of difficulty with stored energy when you pulse the short and the long solenoids very rapidly?

SESSLER, LRL: It depends upon the length. We are attempting to have a solenoid, one meter long, fabricated for our run in September. I don't recall how many kilojoules are involved, but it is in a range in which it can easily pulse. Even if the solenoids were many meters long unless they were superconducting, you would probably always pulse even though the amount of stored energy is rather large.

FEATHERSTONE, CERN: When you think of application of the "electron ring" principle to a practical high energy accelerator, are you brave enough to talk about the number of these rings you might accelerate in a given period of time? Also, what kind of problems does this pose to the user? I presume you are getting rather short bursts of high energy particles.

SESSLER, LRL: Right. As to the number of pulses per second, I think it is best to quote the Soviets who have been studying this problem for about three years -- rather than our six months. They state about one thousand pulses per second. I suppose it can't be much faster than that because of such considerations as the rise time of condenser banks, reasonable voltages, the 100 kilojoules that you need in a typical compressor, and so forth. I think this is a reasonable upper limit. As far as the experimental applications are concerned, I am really not an expert on that. Certainly, people have thought about these at some length and I suppose there are many experiments you can do, but certainly there are many experiments you cannot do.

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DISCUSSION CONTINUED

The experimentalists, at least at our lab, are sufficiently interested in the things they can do, that they are willing to encourage us to go on. I think this is the best way I can answer your question.

HAIMSON, MIT: Referring to the problem of the initial acceleration of the ring and the peristalsis requirement, has a helical microwave circuit been given any consideration? A helix, similar to that used in traveling wave tubes, can provide a relatively constant field strength and a smoothly increasing phase velocity. This is probably better than individual rf cavities separated by graded magnetic fields.

SESSLER, LRL: No, but this might be an interesting possibility. It is especially interesting to consider a multi-start helix, which being rather smooth might greatly reduce the cavity radiation (at high frequencies) -- and thus reduce the beam loading problem.

KNAPP, LASL: Does the pulse line system require peristalsis?

SESSLER, LRL: Probably not. We have not done detailed calculations, but after the first few meters it will not. Jackson Laslett and I have been working for the last few months on tolerances of magnet fields and ripples. We have worked out dynamics in magnet fields with bumps, gradients, holes, etc. It looks like after a few meters, you won't have to worry about peristalsis.

NAGLE, LASL: How would the performance of a pulsed heavy ion smoke ring accelerator compare with the Omnitron performance?

SESSLER, LRL: There is a paper in the conference report (UCRL-18103) on that subject. If you take the premise of 10^{13} electrons or 10^{11} heavy ions per pulse and 10 pulses per second, then it is a factor of 10 poorer then the Omnitron. One can contemplate increasing the number of protons per pulse by a factor of 10. Also, the Russians talk about going to 1000 pulses per second. Thus there are three orders of magnitude disparity between the parameters the Russians contemplate in a real machine and the numbers we take for our first model. With the Soviet parameters, the ERA is 100 times superior to the Omnitron; but don't forget you are comparing a machine that can be built now, with one which may not even work.

CHRISTOFILOS, LRL, LIVERMORE: I have a quite different set of numbers. The repetition rate is 60 pulses per second and if we talk about large rings, we talk about 10^{15} electrons per ring. Then the electron ring accelerator would be about 60 times as intense as the Omnitron rather than 10 times less.

SESSLER, LRL: There is a wide spectrum of parameters we can imagine for this device. We simply don't know much about the physics of electron rings. We want to know, for example, how much we can twist or bend the rings, etc. After that we can design the machine. Peoples' imaginations, right now, are not limited by facts. Some say the number of electrons should be 10^{13} and some 10^{15}. Actually, if you take the same formulas I used for a ring 1 mm across, containing 10^{13} electrons and then increase the size to 1 cm and the number of electrons to 10^{14}, then the formulas scale in different ways and the machine is safer, in all ways, than the machine we are modeling. As you increase the total current and relax the transverse dimensions, you can get the same holding power and you can make the coherent radiation 10 times less and you can increase the space charge limits by a factor of 10. This assumes there is no rule that says you can't have any more than 1000 amperes, but I don't know of any such rule. Until we have more facts, there seems to be a wide range of parameters. At one end of this range is a very powerful low energy high flux device, while at the other end is a convenient high energy (relatively low flux) machine.