

Report on Prototype Spark Chamber

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We started off the project following the document in the given link <http://arxiv.org/abs/1010.4010> "Construction of a Prototype Spark Chamber" by Jack Collins.

Initial Model

In the beginning, we used aluminum plates of size about 25cmx25cm with spacing between them 2.4cm. We followed the shelf model and used 10 plates supplied alternately with high and ground voltages. The circuitry was the simplest possible with only a 10 M Ω resistor placed in the beginning of the circuit before being distributed across the plates.

We used helium(supposedly ~90% purity) for the experiment and were flushing it continuously through the chamber. We had with us a power supply limited to providing 5kV. We went up to its limit in the course of experimentation.

We did not use trigger circuits and scintillators since this was the first time we attempted to build such a chamber and wanted to try out a simplistic model first.

All we saw in this was corona discharge between the plates. A summary of the observations were recorded as follows:

- The chamber was flushed with He for 2-3 minutes initially before we starting building the voltage from 0 V to about more than 4.5 kV.
- We started observing corona discharge inside the chamber beyond 4.5 kV, mostly toward edges.
- The discharge was present between the top 2 plates only.
- The corona discharge didn't stop, after we stopped flushing He inside.
- The corona discharge stopped only after the voltage was brought down below 4 kV.

Then we reduced the gap distance to 1cm but got the same results as above. Since there were instances where we thought some spurious sparks(and not corona) were seen intermittently, we decided that if we could inhibit the corona, then we could observe the sparks. In order to do so, we coated the plates with anti-corona lacquer/acrylic paint(both were tried out one after the other on two different sets of plates) since the scratches on the plates seemed to be the reason for the singularities in the electric field between the plates and hence the corona discharges.

However, as a result of this, the surfaces became non-conducting and neither sparks nor corona was seen. This is where we took a break from the project to reconsider our approach.

Current Model

We revised our calculations for the voltage required and the pressure of helium in the chamber to be maintained. We used the relationship between Townsend coefficient α , electric field E and pressure p :

$$\frac{\alpha}{p} = Ae^{-\frac{Bp}{E}}$$

where A and B are constants for a certain gas(in this case Helium) which were determined from experimental data.

(Refer: "Progress in Nuclear Physics, Vol 9" article on spark chamber:

<https://books.google.co.in/books?id= ffpAgAAQBAJ&printsec=frontcover#v=onepage&q&f=false>)

We estimated that at atmospheric pressure, we needed more than 4.3kV with a gap distance of ≈ 1 cm to induce streamer formation. Further from the dielectric strength of helium, we found that breakdown at 5kV(the voltage we were using) occurs at distance less than 1.1 cm. So we decided to use 1.2 cm between the plates.

To overcome the problem of scratches and unevenness in the plates, we decided to use single sided PCB sheets(Cu layer of $\approx 18\mu\text{m}$ over FR4 insulation) and build a prototype out of only two plates, one of which is connected to high voltage and the other grounded. Additionally, to induce sparking, we kept a beta source above the plates.

However, even now corona was seen to occur at the edges at $\approx 4.5\text{kV}$, although once again, in the initial trials, we saw what we thought to be sparks near the source induced by the beta decays, which was then subdued because of corona discharge. We then tried out several modifications and variants which included:

- Etching out copper from the edges and rounding them
- Taping the edges with insulation tape(corona pierced through the tape)
- Changing gap distance(tried out 6mm, 9mm, 12mm)
- With air(no corona until helium is flushed)
- Adding a guard ring around the main plates which is grounded(corona discharge occurred between the high voltage metal plate and the ring surrounding it)
- Adding desiccant to the chamber to ensure the gas is dry

But in all the above cases, corona discharge took place at one or several points, especially on flushing helium at a higher rate.

This is where we believe we are doing something fundamentally wrong and have decided to retrospect and think about things again.