

Physics. — Conductivity of pure Gases at high pressures. By J. CLAY
and G. VAN KLEEF.

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Summary. The ionization by gamma rays is measured in neon at 97 and 63 atm. and in xenon between 81.6 and 65 atm. It is found that these gases become *conductive* in high electric fields, also without the gamma rays, between certain pressures. The conductivity of xenon at 75 atm, 25° C and at 4000 Volt/cm is 3.2×10^{-15} Amp/Volt. A considerable influence of the temperature is found. The conductivity is also found in other gases but till yet not in air and argon.

In our program to compare the ionization in different gases by cosmic radiation and gamma radiation, we had the opportunity to involve the pure noble gases which we obtained for this purpose from the PHILIPS Works.

In the small ionization chamber (fig. 1) which was constructed for this purpose we needed only 30 cc in the whole vessel and the volume in which the current was measured was 2.7 cc. The distance of the plate electrode, connected to the electrometer, to the other electrodes on both sides was 0.505 cm. The surface of the plate electrode in the middle was 2.65 cm². This electrode was surrounded by a guard plate connected to earth. The ionization currents were always measured by continual compensation by a charge on a calibrated capacity connected to the electrometer.

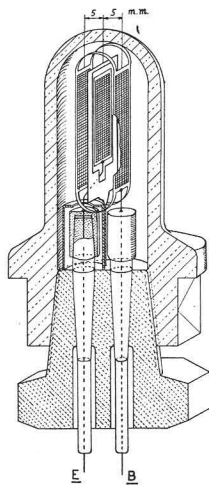


Fig. 1.
Ionization chamber for
high pressures and
high homogeneous
fields.

We measured first the ionization currents in argon (1) by 0.1 mgr *Ra* at 10 cm distance at different pressures up to 100 atm. and collecting fields to 4000 Volt/cm. To find the saturation current we could use the formula of JAFFE—ZANSTRA (2).

After the measurements in argon the chamber was filled with air and the ionization measured and then with neon. The constant for neon in the formula for the HANKEL function was found to be 10^{-2} as is seen from the graph at 97 atm. The field was taken up to 3200 Volt (fig. 2). Then the ionization in neon was measured at 63 atm. and for the voltages below 1600 Volt we found that the two lines at 97 and 63 atm. give a saturation, proportional to the

pressure (fig. 3) so as we had found already for argon (1) and air (3) before. On account of the grid electrodes the influence of the electrodes is so small that it gives no increase.

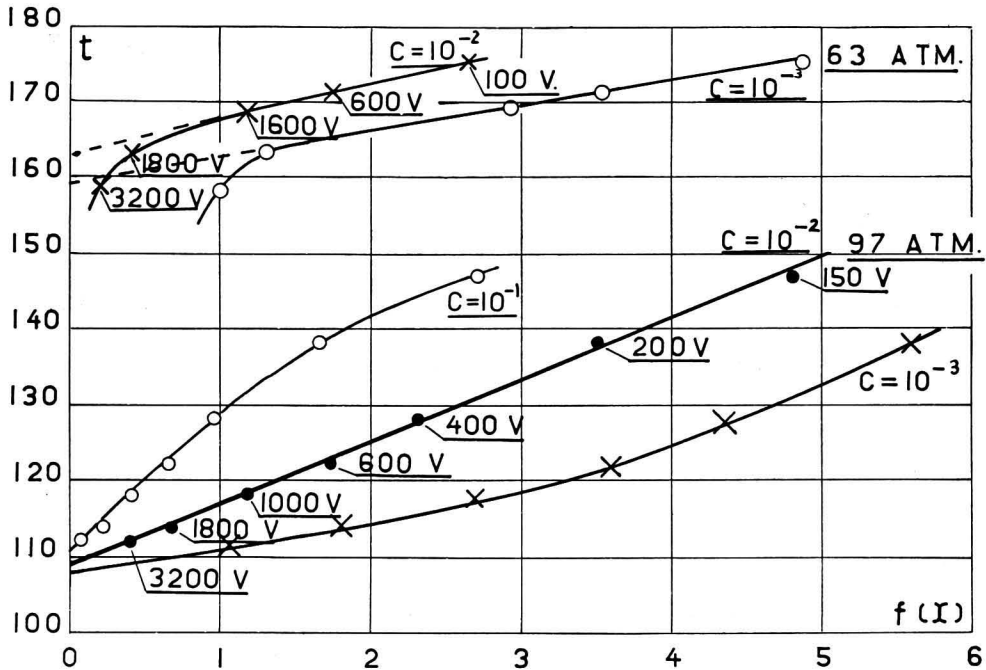


Fig. 2. Ionization by gamma rays in neon at high pressures by different collecting fields. Testing the constant c in the formula $x = c \left(\frac{X}{p} \right)^2$.

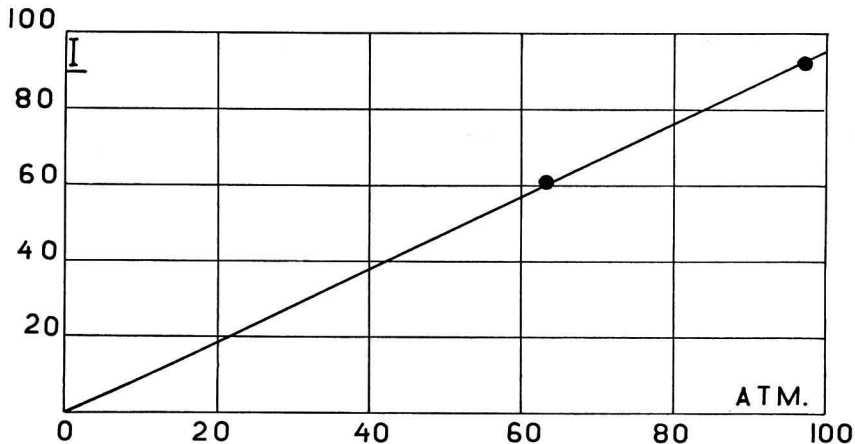


Fig. 3. Saturation value of the ionization in neon by gamma rays at different pressures.

But at the fields above 1600 V we found values for the ionization much too high (too low values of the time of compensation a certain charge) which we could not explain.

The neon was taken out of the vessel and filled with xenon. The

pressure we could obtain at 25° C was 81,6 atm. We found for fields below 1200 Volt/cm that the extrapolation formula could be applied and the best value of the constant in $x = c \left(\frac{X}{p} \right)^2$ was $c = 10^{-3}$ (fig. 4).

But now we saw that for values of the fields above 1600 Volt the same phenomenon as in neon at 63 atm., but much stronger, was observed. It was possible to get a current also without any ionization from outside. We tried to see whether there was any difference when the chamber was surrounded by 11 cm Fe to exclude gamma radiation from outside and soft cosmic radiation, but this did not make any observable difference. From this time on the systematic observations were made in other gases

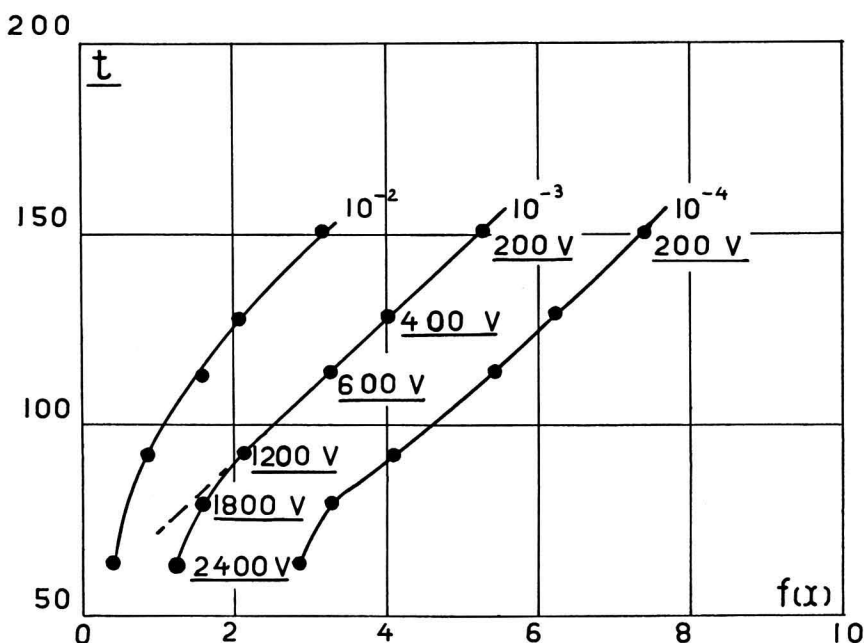


Fig. 4. Ionization by gamma rays in xenon at high pressures by different collecting fields. Testing the constant c in the formula $x = c \left(\frac{X}{p} \right)^2$. Conductivity for high fields.

and we found the conductivity also in nitrogen (4), in helium, in krypton, but till yet not in air and argon. In the graphs we see the ionization currents in xenon directly at pressures of 81.6, 75, 70 and 65 atm. with and without the supplementary ionization of Ra. We see that there is an optimum value of the conductivity in relation to the pressure and the same we found also already in other gases. At first it seemed that it was difficult to reproduce the same value at different moments, but after we found that the influence of temperature is very great, we have seen that by constancy of temperature the values are reproducible within a few

percent. In the graph 6 we see the influence of temperature. This was also found in krypton and in nitrogen already. Our provisional explanation of this conductivity may be that at the high pressures the fields of the atoms come so near to each other that some of the outer electrons are only bound very loose and the energy of the free electrons gathered in high fields, during their free paths is enough to make a larger number of these electrons free. It would explain that at low pressures the first condition is not fulfilled and at high pressures the second condition cannot be

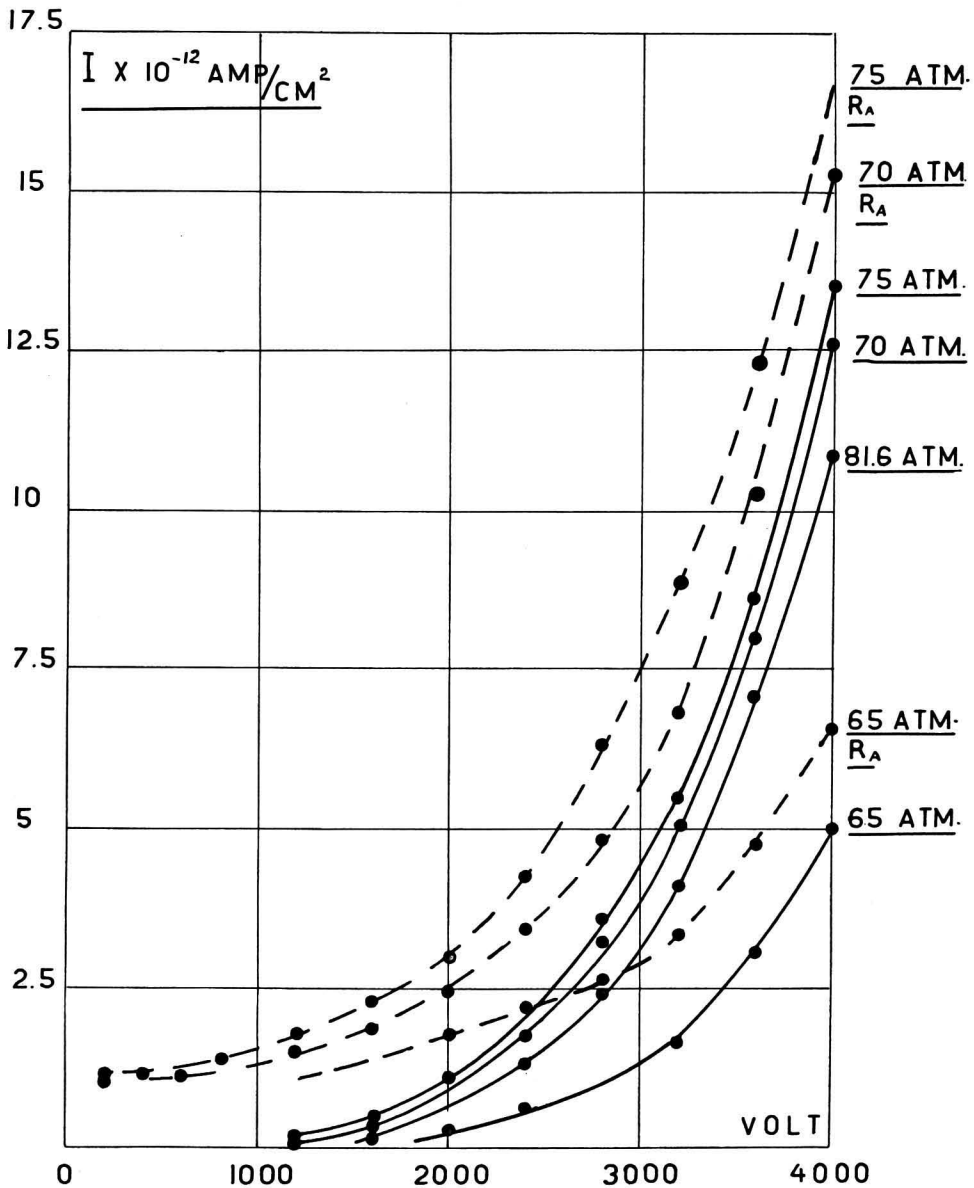


Fig. 5. Conductivity in xenon in different fields at different pressures.

fulfilled. That the conductivity became so high in xenon may be explained because the density we had was more at 81.6 atm. than twice that of water.

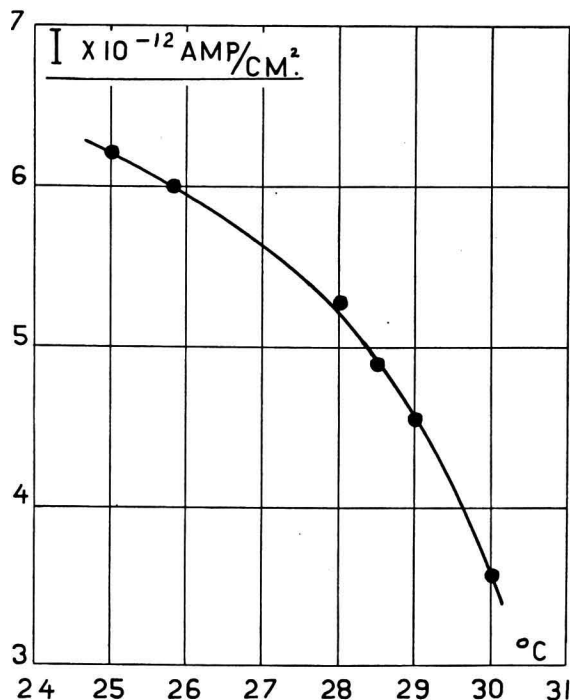


Fig. 6. Influence of the temperature on the conductivity of xenon, pressure of 65 atm. and a field of 3400 Volt/cm.

At 4000 Volt and 75 atm. we got a specific conductivity of 3.2×10^{-15} Amp./Volt at 25° C. We will give the relation to density in xenon in future and we are now following the conductivity for the whole range of pressures below 65 atm. and the influence of temperature. The same is done for other gases. It seems remarkable that we did not find this conductivity till yet in air and argon.

For providing us with the xenon we are highly indebted to the Direction of the PHILIPS Works and especially to Ir. HOLLEMAN and Dr. FILIPPO.

September 15th, 1937.

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