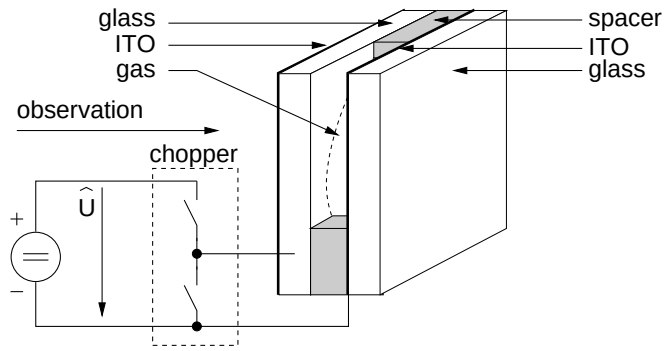

FIG. 6.6: Experimental set-up. Two glass plates of thickness a are separated by a spacer defining a circular gas-discharge space being filled with helium at pressure p and having the discharge length d and the diameter D. The glass plates both are coated with ITO, one of which is oriented to the gas space and the other to the outside. In the latter case the corresponding glass plate acts as a dielectric barrier. Through one of the glass plates the gas-discharge can be observed using a video camera. The system is driven by a positive rectangular voltage with a frequency f, a duty-cycle of 50 % and an amplitude $\hat{U}$.

the electrodes is oriented with the ITO coated side to the gas gap and therefore acts as a metallic electrode. At the other glass plate the ITO layer points to the outer side and hence acts as an electrode with a dielectric barrier with a thickness of $a = 0.5$ mm – 1.0 mm. Through one of the glass plates and the corresponding ITO layer the gas-discharge is observable by a video camera. The working gas in the gas gap is helium at a pressure of $p = 200$ hPa. The electric power supply provides a positive rectangular voltage with an amplitude up to $\hat{U} = 700$ V and a duty cycle of 50 %. The frequency f is varied from 0.1 kHz to 20 kHz.

The first run of the experiment was made by increasing the frequency. The experimental results are depicted in Fig. 6.7. When the system is driven in the range of lower frequencies, a weak glow discharge with fluctuations in the light emission is visible. Figure 6.7 shows such a situation at $f = 6.2$ kHz. At higher frequencies the fluctuations increase, and at approximately 7.4 kHz bright spots occur arbitrarily distributed over the discharge area, as it is shown in Fig. 6.7 for $f = 8$ kHz. Near the bifurcation point it is possible that spots are generated and disappear again. The three pictures in Fig. 6.7 at $f = 8$ kHz represent such a scenario. They are taken from consecutive video frames with a repetition time of 20 ms. In the first frame the upper of three bright spots has just been ignited. In the second frame it is fully developed and in the third frame it has vanished again. As the frequency is further increased more and more spots arise. At $f = 9$ kHz almost half of the discharge area is covered with spots. From time to time some rearrangement of the pattern occurs which becomes increasingly vivid with further increase of the frequency. At $f = 9.3$ kHz the whole discharge area is covered with bright

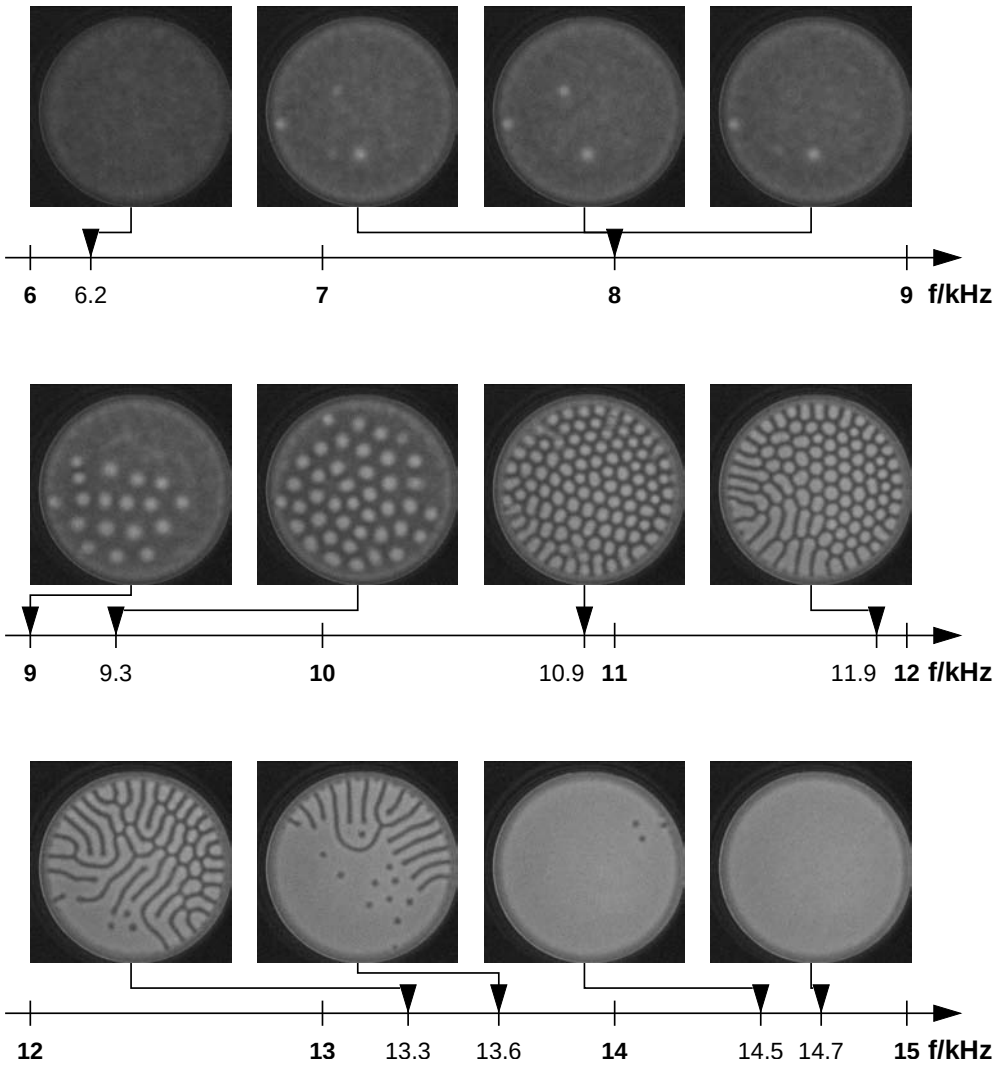

FIG. 6.7: Luminescence radiation density being emitted from the DBD system as the driving frequency f is increased. The three pictures at $f = 8$ kHz are consecutive video frames with a repetition time of 20 ms. The parameters according to fig. 6.6 are $a = 0.7$ mm, $d = 0.5$ mm, $D = 40$ mm, $p = 200$ hPa He, $U = 550$ V, exposure time: 1/250 s.

spots. Due to the large number of spots they are rather near to each other and spots formally having radial symmetry become deformed due to interaction. In Fig. 6.7 at $f = 10.9$ kHz a dense arrangement of deformed spots is shown. For $f \gtrsim 9.3$ kHz the pattern undergoes continuous rearrangement.

When the frequency is increased further, the spots begin to fuse with their neighbours as it is shown in Fig. 6.7 at $f = 11.9$ kHz. Hence for these objects it is no longer evident that they are spots on a dark background. In fact, it seems to be more justified to refer to a bright background with areas of lower light intensity. For further increase of the frequency the pattern consists of a bright background with dark, branched grooves, as it is shown in Fig. 6.7 at $f = 13.3$ kHz. At this point it becomes evident that the dark stripes always

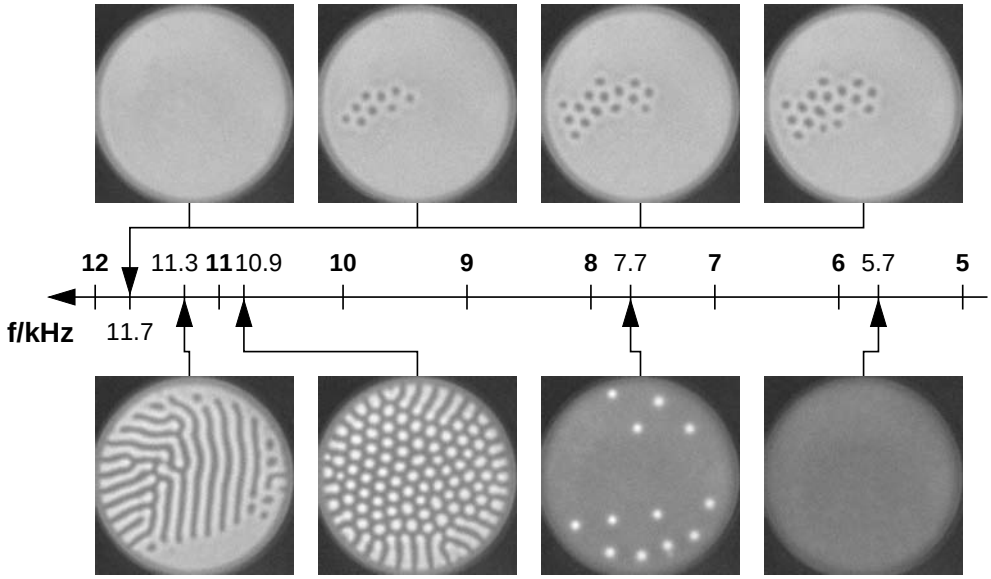

FIG. 6.8: Luminescence radiation density emitted from the DBD system as the driving frequency f is decreased. The four pictures at $f = 11.7$ kHz are consecutive video frames with a repetition time of 20 ms. The parameters and exposure time are as in fig. 6.7

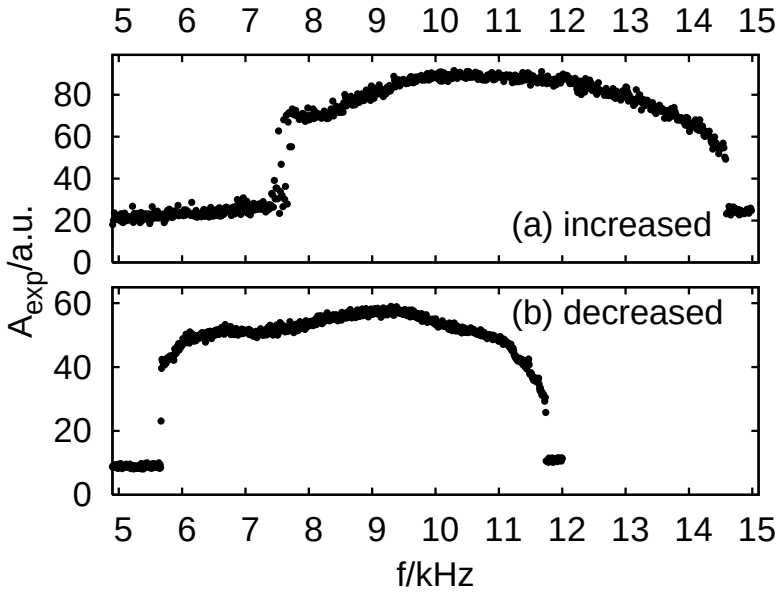

FIG. 6.9: Amplitude difference A_{exp} of the pattern in dependence of the driving frequency: (a) for increasing frequency, evaluated from fig. 6.7. (b) for decreasing frequency, evaluated from fig. 6.8.

hit the boundary of the discharge area at right angle. Eventually some grooves become very short, and if they are as short as they are broad one would prefer to refer to them as spots. When the frequency is still increased further we occasionally observe dark spots (Fig. 6.7 at $f = 13.6$ kHz) performing an irregular shivering and propagation. At $f = 14.5$ kHz the discharge plane exhibits