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Tuning Coler magnetic current apparatus with magneto-acoustic resonance

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Abstract

An attempt was made to tune the Coler magnetic current apparatus with the magneto acoustic resonance of the magnetic rods. Measurements with a replica of the famous Coler "Magnetstromapparat" were conducted. In order to tune the acoustic, magnetic and electric resonance circuits of the Coler device the magneto-acoustic resonance was measured with a frequency scan through a function generator and a lock-in amplifier. The frequency generator was powering a driving coil, while the lock-in was connected to a pickup coil. Both coils were placed on a magnetic rod. Resonances were observed up to the 17th harmonic. The quality Q of the observed resonances was 270. To study the magneto-acoustic resonance in the time domain a pair of Permendur rods were employed. The magneto-acoustic resonances of the Permendur rods were observed with an oscilloscope. Spectra of the magneto acoustic resonance were measured for the Permendur rods and for a Coler replica magnet in the frequency range from 25 kHz to 380 kHz. The next step was to bring the resonances of the Permendur rods close together so that they overlap. The 10th harmonic was chosen because it was close to the 180 kHz that Hans Coler related to ferromagnetism. Further more magneto-acoustic coupling between the Permendur rods was studied. Finally the question was explored if Hans Coler converted vacuum fluctuations via magnetic and acoustic resonance into electricity. There is a strong connection between magnetism and quantum field zero point energy (ZPE). An outlook is given on next steps in the experiments to unveil the working mechanism of the Coler magnetic current apparatus.

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1. Introduction

This article will explore the working principle of a new type of electrical generator which was invented by Hans Coler. In the first part the history and the general description of the device will be given. Important historic facts are the early tests of the device by the well known German Professors Schumann and Kloss. This is one main reason why this invention was not forgotten. Another important historical fact is the investigation of the device by the British Intelligence Objectives Sub-Committee (B.I.O.S.) and the confidential, later disclosed, positive report of this agency. The investigation was conducted by Hurst and Sandberg. Sandberg knew Coler and his work since much earlier and played a major role in convincing the British agency to take up the project. Hans Coler was contracted in 1947 to rebuild the Stromerzeuger and the magnetic current apparatus. This work will present the technical design of a replica of such a Coler device. The replica was built by students of the Technical University of Berlin in 1998 and 1999 under the supervision of Dipl. Ing. Andreas Manthey. The construction of the Coler device was part of a course in interdisciplinary innovation learning. The student group took up the Coler device because there is a rich source of technical information on the device and another important reason was that the original device was positively tested at the same institute in 1926. An investigation to retrieve the original documents in the archives of the Technical University revealed that the documents were missing - a toll taken by a British firebomb during an air raid on Berlin in 1943. Since Coler also presented some theoretical hints on the working principle of his device, this work will also deal with the fundamental properties of magnetism and the feasibility of using electrical and magnetic resonances of ferromagnetic magnets to construct a generator. This article will also present an experimental technique that allows tuning Coler´s device based on the magneto acoustic resonance. The work is still ongoing. This work on the Coler generator was taken up because of the credible witnesses for a proof of principle for a device that works with permanent magnets and no other input power. Since the magnetism of the electron can be explained as a relativistic quantum effect with corrections due to the exchange of energy with the zero-point energy (ZPE) quantum fluctuations [1] and permanent magnetism is today seen as a collective electron phenomenon [2], the Coler device seems to be a good starting point for practically testing the possibility of using magnetism to convert ZPE into useable electric energy. This connection will be laid out in more detail in a later part of this paper.

A major part of the work presented here is the tuning of the Coler magnetic current device with the magneto-acoustic resonance. To find the working mechanism of the Coler device a replica of Coler´s magnetic current apparatus was built and modern measurements on the replica were conducted. In order to get the device to work the magneto-acoustic resonance of the magnetic rods of the Coler device was measured and the rods were tuned to each other. It is planned to construct the electric circuit of the Coler device in such a way that it is tuned to this frequency. A number of tests were done in order to understand the coupling between the magnetic, acoustic and electric oscillations in the magnets.

Nomenclature

Q	quality of a resonance	L	length of rod (m)
E	Young module (N/m^2)	ρ	density
n	natural number, harmonic order	f	frequency
μ_s	magnetic moment of the electron	g_s	gyromagnetic ratio
m	mass of the electron	s	spin number

2. Coler Generator

Hans Coler invented two energy devices by which electrical energy may be derived without a chemical or mechanical source of power. The devices are called the "Magnetstromapparat" (magnetic current apparatus) and the "Stromerzeuger" (current generator). The "Magnetstromapparat" was developed by Coler and von Unruh early in 1933. With this device, consisting only of permanent magnets, copper coils, and condensers in a static arrangement he showed that he could obtain a voltage of 450 mV for a period of some hours. This device consists of six permanent magnets wound in a special way so that the circuit includes the magnet itself as well as the winding, see figure 1. These six magnet-coil combinations are arranged in a hexagon and connected in a circuit which includes two small condensers, a switch, and a pair of solenoid coils, one sliding inside the other [3].

The "Stromerzeuger" consists of an arrangement of magnets, flat coils, and copper plates, with a primary circuit energized by a small battery. Coler and von Unruh made up a slightly larger model with an output of 70 watts. This was demonstrated to Dr. F. Modersohn, who obtained from Prof. Schumann and Prof. Kloss confirmation of their tests in 1926. The device was seen by the professors Schumann (Munich), Bragstad (Trondheim) and Knudsen (Copenhagen). Reports by Prof. Kloss (Technical University of Berlin) and Prof. Schumann (Technical University of Munich) are reliable evidence that the device was real and worked. Prof. Schumann is still widely known for the discovery of the Schumann Resonances in the earth atmosphere. Coler then in 1937 built a larger version with an output of six kilowatts.

Coler and von Unruh built the magnetic current apparatus, which has no input power, as a demonstration unit to convince investors that this is a novel energy device.

The British intelligence started an investigation after 1945. Coler was visited and interrogated. He proved to be co-operative and willing to disclose all details of his devices. He built a "Magnetstromapparat" in 1947 using material supplied to him by the British intelligence (Ministry of Supply). The greatest voltage obtained with this "Magnetstromapparat" was stated to be 12 volts.

Coler had no complete scientific explanation for the working of his device. He stated that his researches into the nature of magnetism had led him to conclude that ferromagnetism was an oscillating phenomenon, of a frequency of about 180 kilohertz. This oscillation took place in the magnetic circuit of the apparatus, and induced in the electrical circuit oscillations. The frequency of these oscillations depended on the values of the components used. These two phenomena interacted, and gradually built up the electric potential. Coler stated that the strength of the magnets did not decrease during the operation of the apparatus. He suggested that a sort of energy hitherto unknown -"Raumenergie" (space energy) was tapped by his device.

3. Technical details of the Coler replica studied in this work

The Coler generator consists of six permanent magnets with coils wound around it and connected to it in a special way. The electric circuit therefore includes the magnets as well as the windings. The six magnet-coil combinations are arranged in a hexagon and connected as shown in Figure 1.

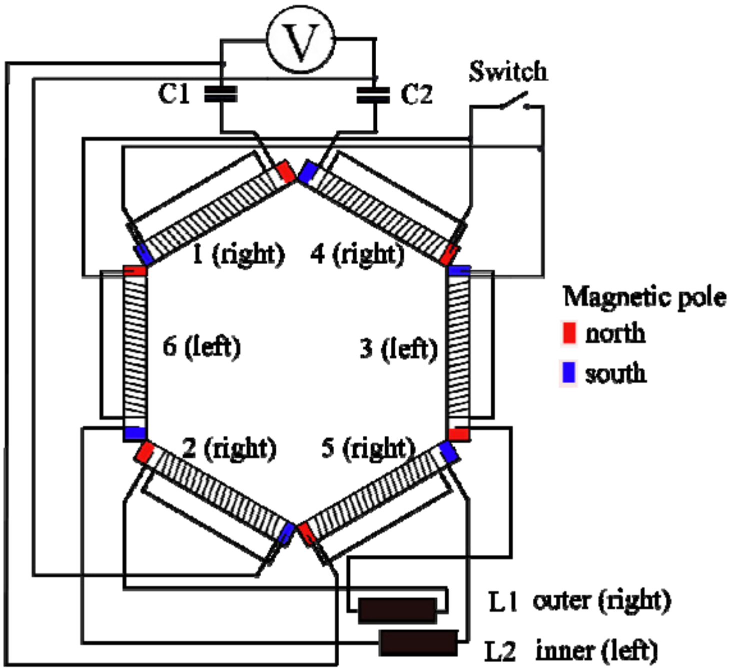

Figure 1. Electric diagram of the Coler magnetic current apparatus.

The circuit includes two small capacitors, a switch, and a pair of air coupled solenoids (L1 and L2) one sliding inside the other. The values of the capacitors were 4.7 nF each. The Coler replica used in this work is shown in figure 2.

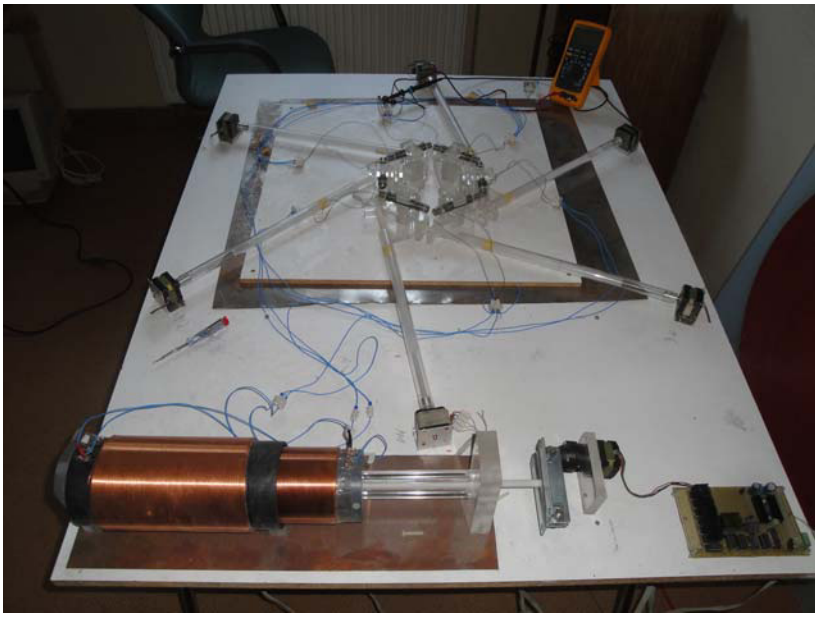

Figure 2. Coler replica built at the Technical University of Berlin

Some of the important uncertainties of the Coler generator are the material of the magnets and the construction and winding of the coil on the magnets. It is unclear if the coils should be wound over most part of the magnets as in figure 1 or only on the edges as in the coil detail figure in the B.I.O.S. report. The magnets were especially manufactured for the original TUB project by IBS Magnet in Berlin. The length of the magnets is 100 mm and the average remanent magnetisation is 200 mT. The measurements on the electric properties and the power output of the Coler device are given in a SPESIF 2011 paper that can still be downloaded for free at Elsevier Physics Procedia [4]. In the more recent work presented here the magneto-acoustic effect was used to tune the Coler magnetic current replica and to obtain an understanding of the working principle. In the next section the fundamentals of the magneto-acoustic effect will be explained and measurement data on the Coler replica magnets will be given. The tuning process will be described in section 5.

4. Magneto-acoustic resonance

The magneto-acoustic effect is the coupling between time-varying magnetic fields (ac magnetic field) and mechanical vibrations also called acoustic or sound waves. If in air, the mechanical vibrations of an object, in our case metal rods, induce compression waves in air that can be heard or picked up by a microphone. The magneto-acoustic resonance is the case when the frequency of an ac magnetic field induces a standing sound wave in the rod. In resonance the ac magnetic field can induce large amplitude sound waves in the rod. To study the magneto-acoustic resonances of the magnets in the Coler generator, a magnet was removed and two coils were placed on the magnet, see figure 3. The coils can slide on the magnet and are not tightly fixed. This is done so that the magnet can move and physically vibrate inside the coils.

Figure 3. Coler replica magnet with driving coil (right) and pick-up coil (left) to study the magneto-acoustic resonance

The magnetic field of the driving coil forces the magnetic domains and domain walls in the magnet or magnetic material to shift. The size of the magnetic domain is coupled to the physical dimension of the material via magnetostriction. The magnetization of a ferromagnetic material is in nearly all cases accompanied by changes in physical dimensions. The resulting strain is called magnetostriction. The dimensions of the material thereby depend on the magnetic orientation in the domain. The ac magnetic field can thereby force sound (physical) vibrations in the material. The reverse effect of magnetostriction induces an electromotive force in the pick-up coil, The physical vibrations in the magnet or magnetic material create a time-varying magnetic field that can be picked up with a coil. Only longitudinal waves couple with the magnetic field of the coils. Transversal waves do not induce or generate an electromotive force (emf) in the coil [5], [6]. In forced oscillation the object is vibrating at the forced frequency. The resonance frequencies are determined by the frequencies of the standing waves of the oscillation that is forced, in this case the physical or sound waves of the magnets or metallic rods. To study the magneto-acoustic resonance we used not only the magnets of the Coler replica but also two Permendur rods that were provided to us by Mark Snoswell, see figure 5. Permendur consist of 49 % iron, 49 % cobalt and 2 % vanadium. The saturation magnetostriction change of unit length of Permendur is $6x10^{-5}$ and is one order of magnitude larger than for iron. The electromotive force generated by the Permendur rods in the case of the magneto-acoustic resonance is orders of magnitude larger than the emf generated by the Coler magnets [7]. First we want to look at the spectrum of a metallic rod.

4.1. Spectrum of longitudinal sound waves in a metallic rod

The frequency of standing longitudinal waves in a rod depends on the length of the rod L, the Young module E and the density ρ of the material.

$$f_n = \frac{n}{2L}\sqrt{\frac{E}{\rho}} \tag{1}$$

The number n is a natural number and determines the harmonic. Higher harmonics have more nodes. Figure 4 shows the 4th harmonic of a longitudinal standing wave in a rod. The positions of the nodes and antinodes and the frequencies of the spectrum also depend on the boundary conditions, in this case on how the rod is held in position. If one end of the rod is clamped, the formula for the resonances is different. In our case the calculation is based on a free rod [8].

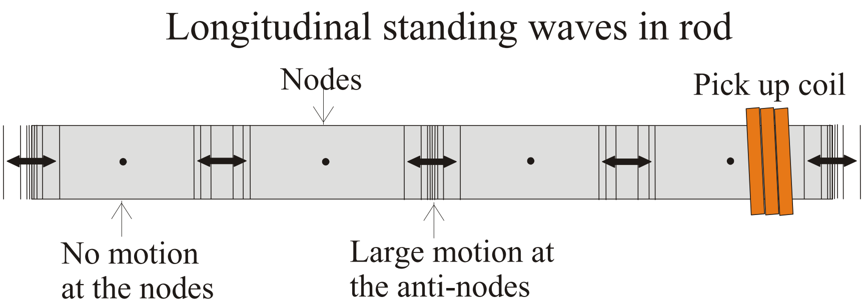

Figure 4. Standing longitudinal waves in rod and pick-up coil. The coil picks up the electromotive force generated by the physical movement in the magnetic rod. Large movement generates a large electromotive force

The physical parameters for the Coler replica magnets are: length L =100 mm, density ρ= 7900 kg/m^3 and Young modulus E=180 GN/m^2. The physical parameters for the Permendur rods are: length L= 151, density ρ= 8150 kg/m^3 and Young modulus E=190 - 240 GN/m^2. The young modulus for the Permendur has a large range. The Young module depends on the stiffness of the material and depends on the production of the alloy and the hardening process. The Young module was determined by fitting the value to the observed resonance frequency spectrum.

Table 1 and table 2 show the calculated and measured magneto-acoustic frequency spectra for a Permendur rod and for the Coler replica magnet.

Table 1 Longitudinal standing waves in Permendur rod with 151 mm length

L (m)	density (kg/m)	Young modulus (N/m2)	c=sqr (E/d) (m/s)	n	2L (m)	frequency (Hz)	Experiment (Hz)
0,151	8,15E+03	2,33E+11	5,35E+03	1	0,302	17712	
0,151	8,15E+03	2,33E+11	5,35E+03	2	0,302	35425	
0,151	8,15E+03	2,33E+11	5,35E+03	3	0,302	53137	53216
0,151	8,15E+03	2,33E+11	5,35E+03	4	0,302	70850	70849
0,151	8,15E+03	2,33E+11	5,35E+03	5	0,302	88562	88384
0,151	8,15E+03	2,33E+11	5,35E+03	6	0,302	106275	105793
0,151	8,15E+03	2,33E+11	5,35E+03	7	0,302	123987	123013
0,151	8,15E+03	2,33E+11	5,35E+03	8	0,302	141700	140043
0,151	8,15E+03	2,33E+11	5,35E+03	9	0,302	159412	156783
0,151	8,15E+03	2,33E+11	5,35E+03	10	0,302	177124	173193
0,151	8,15E+03	2,33E+11	5,35E+03	11	0,302	194837	189183
0,151	8,15E+03	2,33E+11	5,35E+03	12	0,302	212549	204663

Table 2 Longitudinal standing waves in the Coler replica magnet with 99 mm length

L (m)	density (kg/m)	Young modulus (N/m2)	c=sqr (E/d) (m/s)	n	2L (m)	frequency (Hz)	Experiment (Hz)
0,099	7,90E+03	1,80E+11	4,77E+03	1	0,198	24107,80	
0,099	7,90E+03	1,80E+11	4,77E+03	2	0,198	48215,59	48807
0,099	7,90E+03	1,80E+11	4,77E+03	3	0,198	72323,39	
0,099	7,90E+03	1,80E+11	4,77E+03	4	0,198	96431,19	96289
0,099	7,90E+03	1,80E+11	4,77E+03	7	0,198	168754,58	
0,099	7,90E+03	1,80E+11	4,77E+03	8	0,198	192862,37	
0,099	7,90E+03	1,80E+11	4,77E+03	11	0,198	265185,76	263223
0,099	7,90E+03	1,80E+11	4,77E+03	12	0,198	289293,56	
0,099	7,90E+03	1,80E+11	4,77E+03	13	0,198	313401,35	300890
0,099	7,90E+03	1,80E+11	4,77E+03	15	0,198	361616,95	356968
0,099	7,90E+03	1,80E+11	4,77E+03	17	0,198	409832,54	419178
0,099	7,90E+03	1,80E+11	4,77E+03	18	0,198	433940,34	

The test rig of the Permendur rods is shown in figure 5. The Permendur rods were used to study the magneto-acoustic resonance directly on the oscilloscope. The magneto-acoustic effect of the Coler replica magnets is not strong enough to be seen directly on the oscilloscope. The resonance can be studied with a set up using a lock-in amplifier and a frequency generator that scans through the frequency range.

Figure 5. Magneto-acoustic test rig with the two Permendur rods

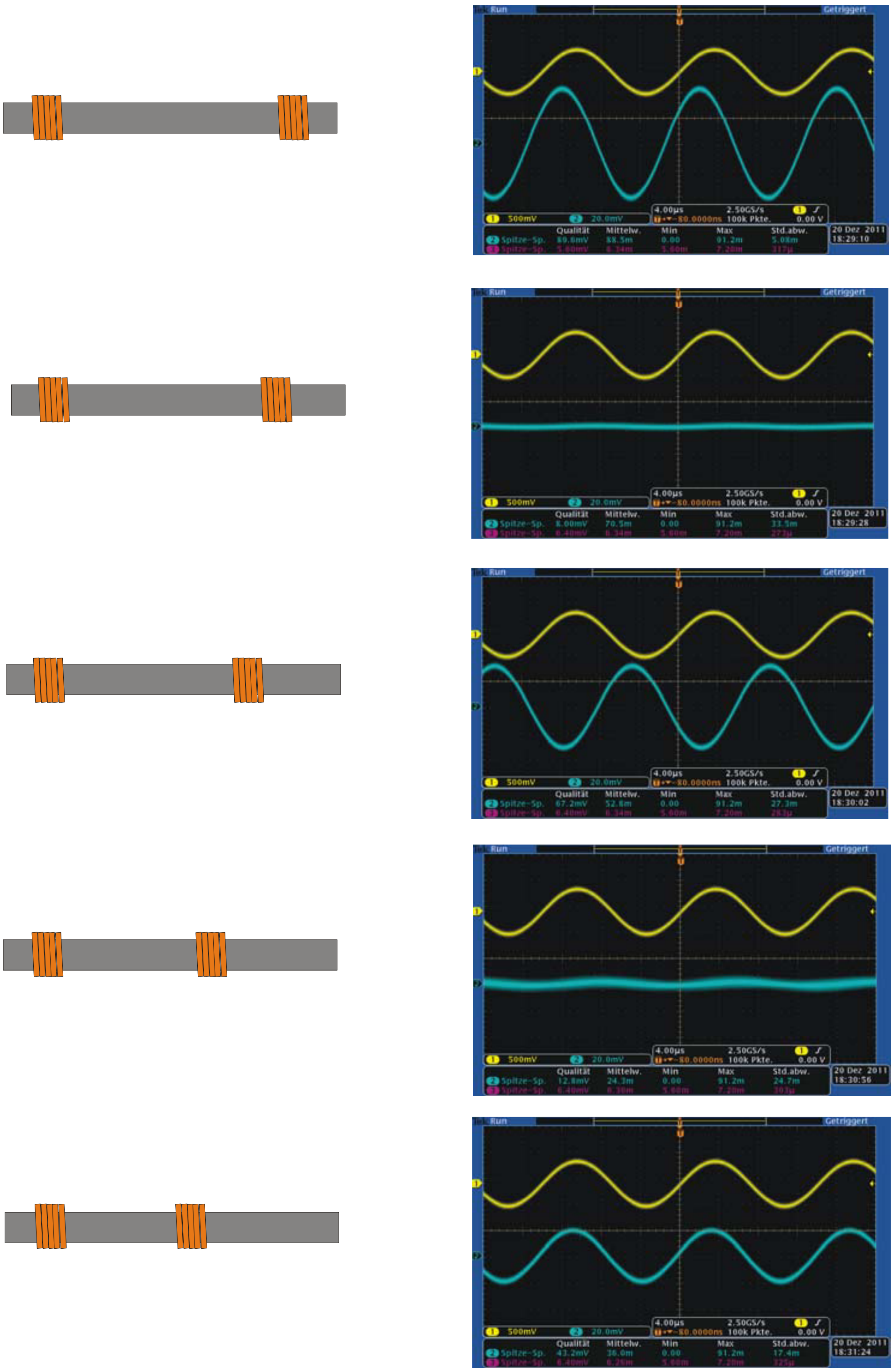

Figure 6. Oscilloscope pictures and pictograms of the position of the driving (left) and pick-up coil (right). The yellow graph is the voltage across the driving coil, the blue graph shoes the voltage of the pick-up coil. No voltage is generated at the nodes. Note the phase shift at the second anti-node in graph 3, compared to graph 1 and 5.

Figure 6 shows the voltage generated in the pick-up coil for different positions on the Permendur rod in the case of the 70,9 kHz magneto-acoustic resonance. The amplitude of the voltage is large close to antinodes. Here there is also a large amplitude in the longitudinal standing wave in the rod. The amplitude is close to zero at the nodes (line 2 and 4). The 180° phase shift between line 1, 3 and 5 is caused by the direction of the compression at these antinodes. If the longitudinal waves in 1 and 5 have a maximum it has a minimum in 3 and vice versa.

4.2. Precision frequency scans to acquire spectra of the magneto-acoustic resonances in the rods

The method used in this project to find the magneto-acoustic resonance of the Coler replica magnet and the spectra of the Permendur rods was based on the lock-in technique. The setup consisted of a function generator, a lock-in amplifier, an analog-to-digital (A/D) converter and a measuring computer. The computer controlled the frequency of the function generator and read in the value of the lock-in amplifier via the A/D converter, see figure 7. The frequency was slowly scanned over the desired frequency range. Since the magneto-acoustic resonance has a high quality (q), the time at each frequency point needed to be long enough for the resonance to set in.

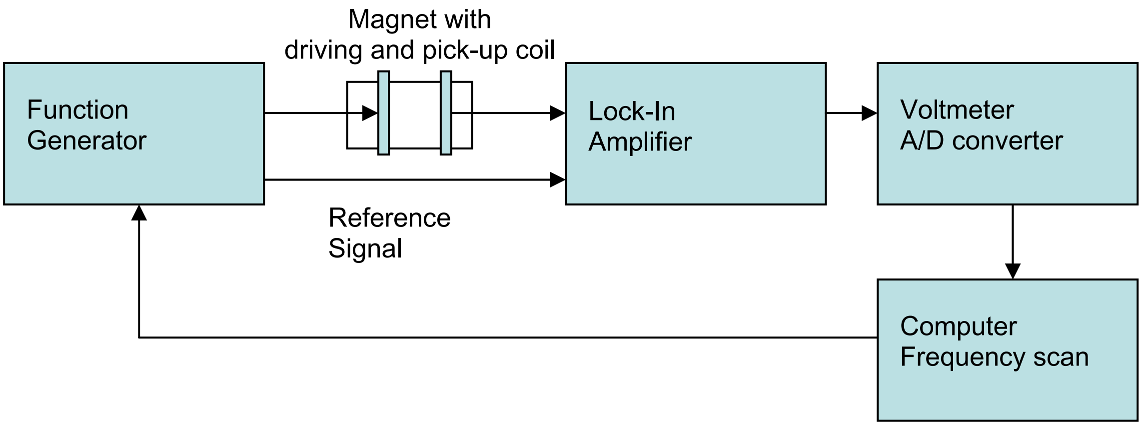

Figure 7: Diagram showing the set up to find the magneto-acoustic resonances.

The resonance and spectra shown in figure 8 to 10 were acquired with the lock-in card and the A/D converter of an Anfatec AFM. The time constant used was 100 ms. The drive voltage was 5 V. First the frequency range from 20 kHz to 380 kHz was scanned to measure the spectrum shown in figure 8. To acquire individual resonance shown in figure 9 the frequency range was set to 3 kHz before and after the resonance. To measure the resonance at 70 800 Hz the frequency range from 68 kHz to 74 kHz was scanned, see figure 9. Usually one scan consists of 512 steps. It is important to stay on one frequency for at least .5 sec if the time constant is 100 ms, in order for the resonance to build up. A single scan took around 5 minutes, independent of the frequency range. The scans for wide range scan spectra like figure 8 and single peak close ups like figure 9 take the same total acquisition time, if they both have the same number of steps. If the frequency steps are too far apart it is possible to miss individual resonances. For wide scans the number of steps should be increased, the roll of (here usually 12 dB) should be lowered or the frequency span should be divided into several intervals and measured separately.

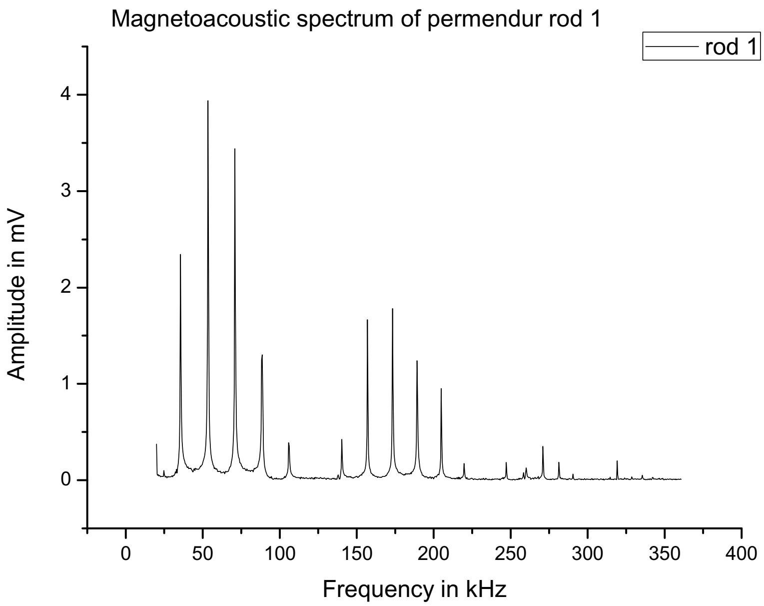

Figure 8. Magneto-acoustic resonance spectrum of the Permendur rod

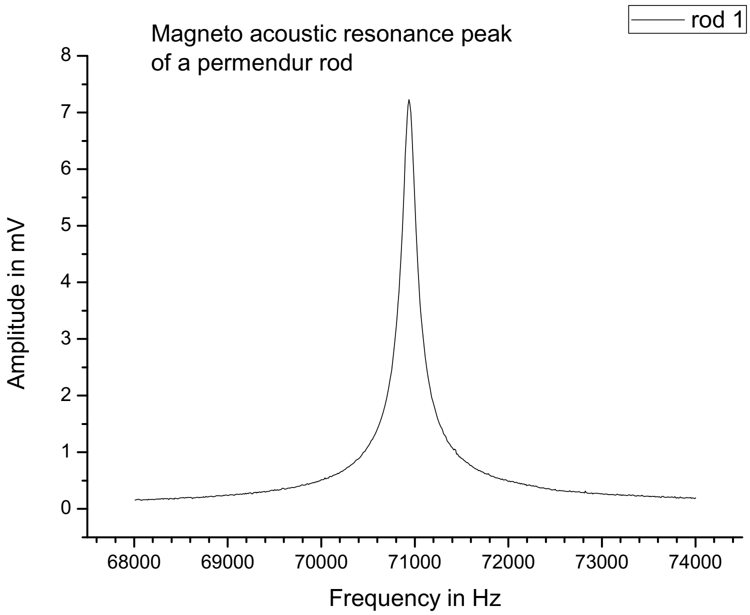

Figure 9. Magneto-acoustic resonance at 70800 Hz

The spectrum shows a significant structure, see figure 8. The amplitude of the resonance peaks shows an overlay function. It starts with small resonances at the basic resonance frequency and shows a first maximum around 53.2 and 70.8 kHz. The resonance at 123 kHz is very low in amplitude, so the overlay has a minimum here. The next maximum in amplitude is around 175 kHz and the next maximum after that is at 270 kHz. No solid explanation for this structure has been found so far. To test the dependence of the resonance amplitude variation spectra were acquired for different positions of the pick up coil. The amplitude structure remained very similar for different positions. We draw the conclusion that the structure of the overlay is not a simple function of the position of the pick-up coil.

Another interesting feature of the Coler replica magnet spectra is the fine structure of the higher harmonics, see figure 10 a and b.

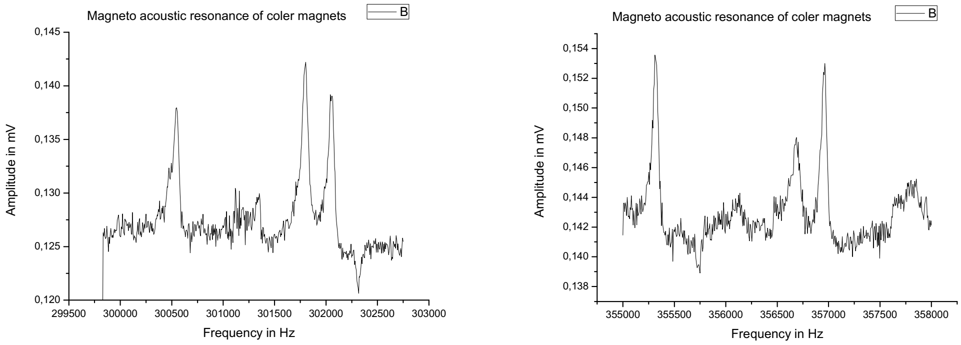

Figure 10. Higher harmonics of the magneto-acoustic resonance in the Coler replica magnets, (a) 300 kHz (left), (b) 350 kHz (right)

The fine structure or multiple peak resonances suggest that there is a mixing of different frequencies. The origin could be a mixing with transversal or torsion modes of the rod, but a number of other causes are possible. No convincing explanation has been found yet. The multiple peaks are a hint that different mechanisms are interlinked by nonlinearities in the ferromagnets. These nonlinearities link magnetic, electrical and physical vibrations in the magnet and allow energy transfer from one vibrational system and mode to another. These nonlinearities can also transfer energy from one harmonic to the next, this phenomenon is also known as frequency doubling. In case the Coler generator converts vacuum fluctuations into usable energy this mechanism could be important, as there is more energy in the higher frequency ranges of the zero-point energy. This mechanism could be important for the function of the Coler generator.

5. Tuning the Coler device with magneto-acoustic resonance

5.1. Tuning the magneto- acoustic resonance of two magnetic rods

In order to tune the Coler magnetic current device to one frequency, it is necessary that all 6 magnets have a similar magneto-acoustic resonance frequency. The resonance peak has to have significant overlap, see figure 11. To tune them it is possible to shorten them a few hundreds of a mm in length. According to formula (1) the length determines the resonance spectrum if the rods are of the same material.

After the frequency of the magneto-acoustic resonance has been tuned, the electric circuit of the Coler device, consisting of the capacitors C1 and C2, the air tuning coil L1 and L2 and the induction of the coils around the magnets has to be set to the same frequency or an harmonic of this frequency, see figure 1.

In order to study the underlying effects in the Coler generator first the two Permendur rods were tuned. Figure 11 shows the overlap of the resonances in the Permendur rods. The tests were done in the test rig shown in figure 5.

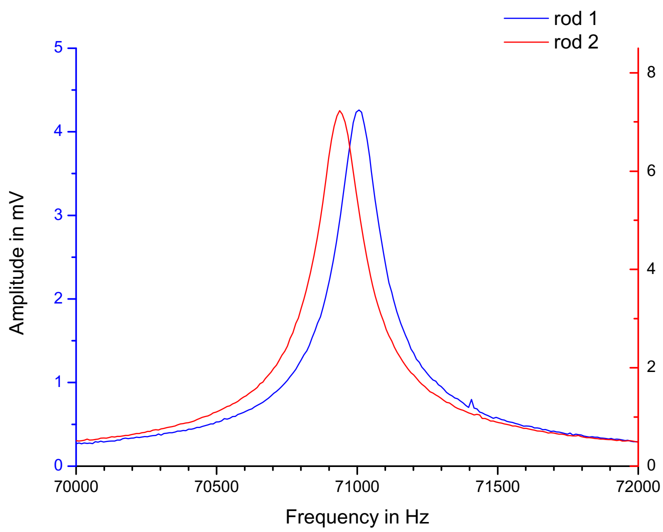

Figure 11. Overlap of the 70.8 kHz resonance in the two Permendur rods. Red curve is rod 1, blue curve is the resonance of rod 2

The coupling between the two rods was tested. First a magnetic ring consisting of the 2 Permendur rods, neodymium magnets and soft iron to close the loop was tried. There was no significant coupling measured. In a second experiment the two parallel rods were brought closer and closer together. In a distance of less than 15 mm significant coupling was measured.

Another experiment to understand the possible mechanism in the Coler generator consisted in sending a current through the Permendur rods when in magneto-acoustic resonance. The spectra showed no significant change. A high resolution scan of one resonance may still show a significant shift in resonance frequency. This experiment will be done soon.

5.2. Barkhausen noise as a possible mechanism to excite the Coler magnetic current apparatus

Coler designed the magnetic current apparatus to show that his current generator that he invented earlier could also work without input power. A mechanism that might excite the no-input Coler magnetic current apparatus is the Barkhausen noise. The Barkhausen effect is closely related to the magneto-acoustic effect. The main difference is that the Barkhausen effect occurs also in very slowly changing magnetic fields. When the magnetization in a material is changed there can be sudden jumps in the magnetization. One cause is that the domain wall movement can make jumps when the domain wall is released from being pinned, for example by a dislocation or grain in the material. The snaps excite acoustic waves in the frequency range from 10 to 500 kHz. Due to the high frequency, Barkhausen noise is usually a surface phenomenon [5]. The mechanism in the Coler magnetic current apparatus could be the following. The enlargement of the magnet separation could cause a change in magnetization of the magnet and this could lead to a Barkhausen noise spike. If this sound has the right frequency component it could excite a magneto-acoustic resonance in the magnet. The magneto-acoustic emission generates an emf in the coil and the induced voltage is connected to another coil that will excite a magneto-acoustic resonance in the next magnet and so on.

5.3. Further tuning process of the Coler device and next experiments

In order to test the underlying mechanism of the Coler device a simple electric circuit has to be designed that is suitable to work with only two magnets or magnetic rods. Coler provided such a two magnet design for the Stromerzeuger [3]. It is planned to study this simplified set-up in order to avoid the tuning of 6 magnetic coils of unknown design and 4 electric components of unknown value. This simplified circuit should have coils around the magnets or magnetic material rods, capacitors and an air tuning coil.

The next step will be to use 4 magnets. This procedure should help to unveil the working principle of the Coler device. If the working principle is clear it will be possible to construct the 6 magnet version of Colers magnetic current apparatus. The information on the Stromerzeuger seems to be very helpful to understand the Coler device.

Another effect that might contribute to the modulation of the internal voltage of the Coler device is the magnetoresistance. If the magnetization of a magnetic material is changed in many cases also the resistance changes [5]. A time varying magnetization therefore will lead to time varying amplitude of the electric current in the magnet. In Coler's design the current has to pass through the magnet. This feedback could contribute to generate an ac current from a time varying magnetization. If the time constant of this feedback mechanism is tuned to the other resonances a build-up of amplitude could be possible. In order to tune this mechanism, it is planned to experimentally determine the time constant of the feedback for the Coler replica magnets and the Permendur rods.

6. Extracting energy from the vacuum state via magnetism and QED as a possible origin of the electric energy output of the Coler device

In order to understand Coler´s device and how electrical energy can be generated with a combination of magneto-acoustic resonance and an electrical resonance the origin of magnetism in general is explored. The modern view point of ferromagnetism is that it is a collective effect of electron spins [2]. The spin itself can be calculated with QED and the Dirac equation. It is one of the most important achievements of the relativistic quantum mechanics that the Dirac equation for an electron in an external field produces almost the right magnetic moment of the electron. The magnetic moment μ_s of the electron is given by

$$\mu_s = -g_s \frac{e}{2m_0} s \tag{2}$$

In equation (2) g_s is the gyromagnetic ratio, e is the elementary charge, s the spin quantum number and m_0 the mass of the electron. In the classical case g is expected to be 1.

The experimental value for g given by Dehmelt [9] is 2.02319304376(8).

The expert is not surprised by this as the magnetic field can be seen as a relativistic effect of the electric field [10]. The Dirac equation results with a g_s of 2. The difference of the experimental value to g_s is called g-2. The difference can be calculated to a high precision with QED. This process is called radiation correction, as the difference g-2 is the result of energy exchange with the vacuum fluctuations, also called radiation field or zero-point energy. Schwinger was the first one to show that the magnetic moment can be calculated from QED [11]. His result for g-2 is α/π, with α being the fine structure constant. Luttinger showed a simpler way to arrive at this result [12]. Masperi gives a more qualitative and understandable explanation [13]. These calculations have been experimentally verified for example by the single electron experiment of Dehmelt [9].

The modern view of the magnetic moment of the electron is that it can be calculated from quantum field theory. The magnetic moment of the electron is partly connected with the vacuum fluctuation because the g-2 part is caused by interaction with the radiation field. Permanent magnetism or remanence is today seen as a collective phenomenon of single electron magnetic moments [1], [5]. It is therefore justified to investigate permanent magnetism as a means to convert vacuum state energy into other forms of energy, *i.e.*, electricity. Puthoff and Cole [14] have shown that in principle this energy can be extracted from the vacuum. Coler may have found a mechanism that converts zero-point energy into usable electricity. He points out that he uses a special resonance of magnetic and electrical vibrations in ferromagnetic material, especially iron. Since ferromagnetism is a collective effect, it can be seen as a self-organized dissipative structure. This holds especially for the ferromagnetic resonance. Therefore ferromagnetic materials combine fundamentally vacuum fluctuations and dissipative structures. The self-structuring process of the electrons in ferromagnetic material could be a way to cohere vacuum fluctuations. This would make ferromagnetic materials ideal candidates to fulfill the requirements laid out by King [15] for processes that extract energy from the vacuum state. In order to verify the connection between Coler magnetic current apparatus, magnetism and energy extraction from the quantum vacuum field it is planned to use Casimir force measurements [16].

The tuning of the magneto-acoustic resonance frequencies and the resonance frequency of the electrical circuit as in the Coler devise might be a way to convert vacuum fluctuations into usable electrical energy. In order to understand Coler's device and to engineer technology from it, a better understanding of the dynamics of ferromagnetism and the coupling to electrical and mechanical vibrations is needed. Research in magnetic nano-structures, magnetic material, magneto-acoustic resonance, spin waves, single-spin magnetic resonance force microscopy and magnetic semiconductors is likely to lead to these needed new insights.

7. Conclusions

Magneto-acoustic resonance is used to tune the magnets and coils to their natural resonance frequency. The spectrum of the magneto-acoustic was measured for Permendur rods and for the permanent magnets used in the Coler apparatus. The position of the coils was varied and the optimal positions match with

Coler's design. The basic frequencies were 18 and 25 kHz, so higher harmonics could well account for the 180 kHz that Coler mentioned in the British intelligence report. Coler's more powerful invention, the Stromerzeuger (current generator) is designed with a driving coil, which makes it even more likely that the magneto-acoustic resonance is part of the working principle. The self-powered magnetic current apparatus could be excited via Barkhausen noise. More experiments will be necessary to totally unveil the working principle of the Coler device and to reach the power output reported by the testifying professors mentioned in the introduction.

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