Cross Modulation between 0S0, 0S2 and the Tides

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Abstract: If strong earthquakes stimulate the earth to vibrate, a high-frequency amplitude modulation can be measured in addition to the exponential decrease in amplitude. The precisely defined modulation frequencies (sums and differences of known natural frequencies) can be explained by nonlinear laws within the earth. Four spectral lines may be generated by the movement of the Earth's core relative to the Earth's crust. Thus, the long-sought Slichter triplet could be identified.

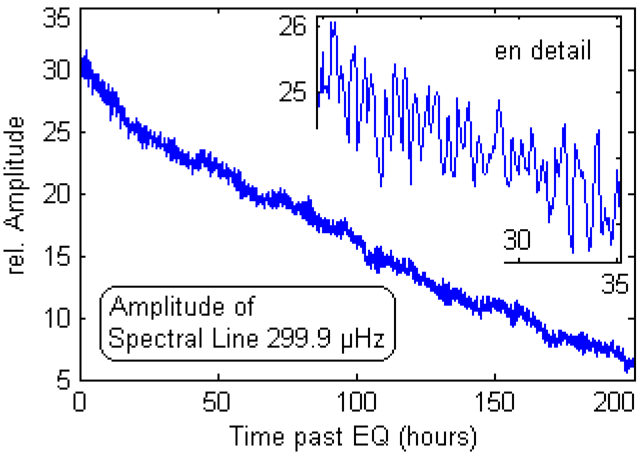
Introduction

After earthquakes, the Earth vibrates like a bell at different frequencies and the whole set of different natural frequencies is recorded by various instruments[1]. Since the natural resonances have very low amplitudes (less than 0.1 mm), it was assumed that they can be fully described with linear physical laws. But this is contradicted by the fact that combination frequencies can be measured, which require sufficiently strong non-linearities. It is unclear where these occur.

Fast Amplitude Variations of $_0S_2$

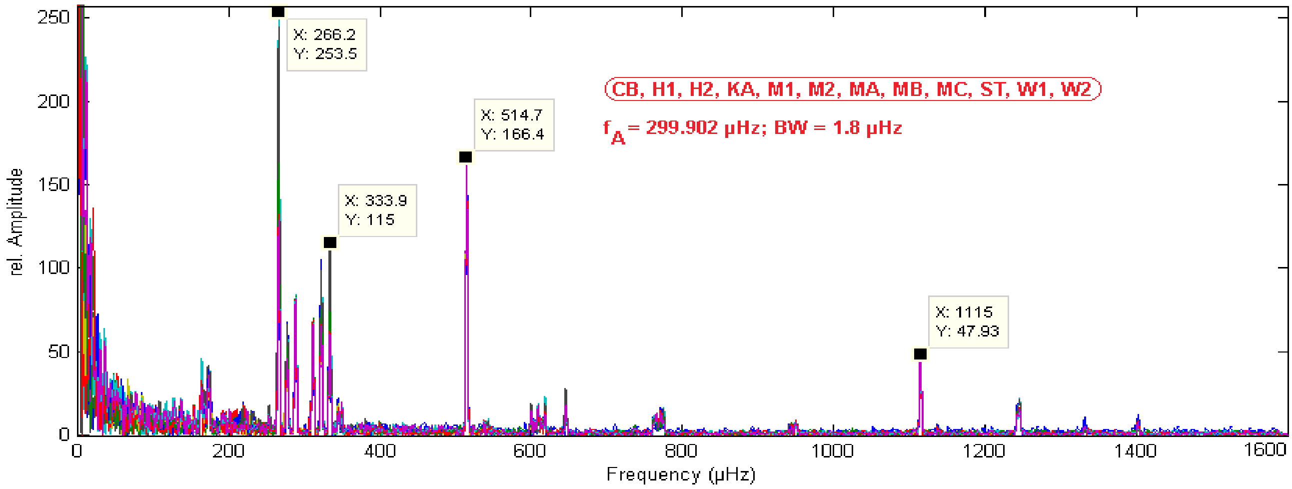
The CORMIN-data of twelve SG-stations were bundled into separate two-year-clusters (The data of S1 and S2 were ignored because the amplitude reduction deviates too much from the exponential curve). To prevent the generation of broadband noise by numeric overload of the mathematical coprocessor inside the computer, the very strong spectral lines below 22 µHz were attenuated by narrow notch filters[2]. The measurements start 8725 hours past 2004-1-1 and end 200 hours later when the $_0S_2$ signal gets too weak. Since previous studies have shown that all the spectral lines of $_0S_2$ quintet are frequency modulated with $f_m = 4.62$ µHz[5], the length of all data segments *must be* an integer multiple of the oscillation period ($T_m = 60.2$ hours). Therefore, the segment length 3612 minutes was chosen for measuring the average amplitude.

The start time of consecutive segments was incremented in five minute steps in order to achieve a sufficient time resolution. A narrow band Sinc filter (bandwidth = 1.8 µHz) largely eliminated the interference without destroying the necessary sidebands. The attenuation of all frequencies outside this range is at least 80 dB. In particular, this large factor 10000 excludes that even small shares of the much higher and powerful $_0S_0$ frequency 814.66 µHz appear in the spectrum of the quintet $_0S_2$. The center frequency of the filter could be switched either to $f_A = 299.9$ µHz or $f_B = 304.6$ µHz or $f_C = 309.3$ µHz or $f_D = 313.8$ µHz or $f_E = 318.4$ µHz.



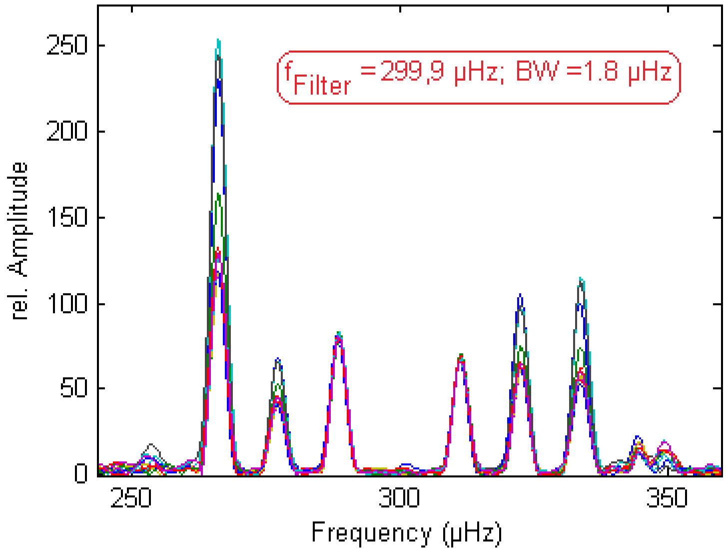
For each SG-station and each of the five spectral lines, the average amplitudes of 2400 periods (length = 60.2 hours) were calculated. The picture shows one amplitude decay measured by H1. The results from other stations are very similar. The resulting curve is apparently composed of two components. Subtracting the slow exponential decay $A = A_0 \cdot e^{-t/T}$ with $T \approx 139 \pm 2$ hours, the high frequency residual is *no noise at all* but shows a remarkable spectral composition. The high-frequency components discussed

a) 13. July 2015, email: herbertweidner@gmx.de below do *not* depend on the bandwidth. The spectrum of the *high frequency residual* shows that the natural resonances of the earth interact with each other and generate new frequencies.



The figure below shows that the central group around the filter frequency is a very symmetrical structure with a gap at the location of the filter frequency. The difference frequencies in the right column of the table correspond to strong tidal waves, which are generated by the sun and moon. The short data length of only 200 hours does not allow a finer resolution.

Frequency (µHz)	f-299.9 µHz
266.221	-33.679
277.348	-22.552
288.703	-11.197
311.368	11.468
322.615	22.715
333.824	33.924



Most interesting are the two solitary spectral lines near 514 µHz and 1115 µHz, produced by a non-linear process. The sum and difference of these two frequencies uncovers their origin.

$$f_{1A}+f_{2A}=(514.687+1114.634)\,\mu Hz=2\cdot 814.66\,\mu Hz=2\cdot f_{0S0}$$

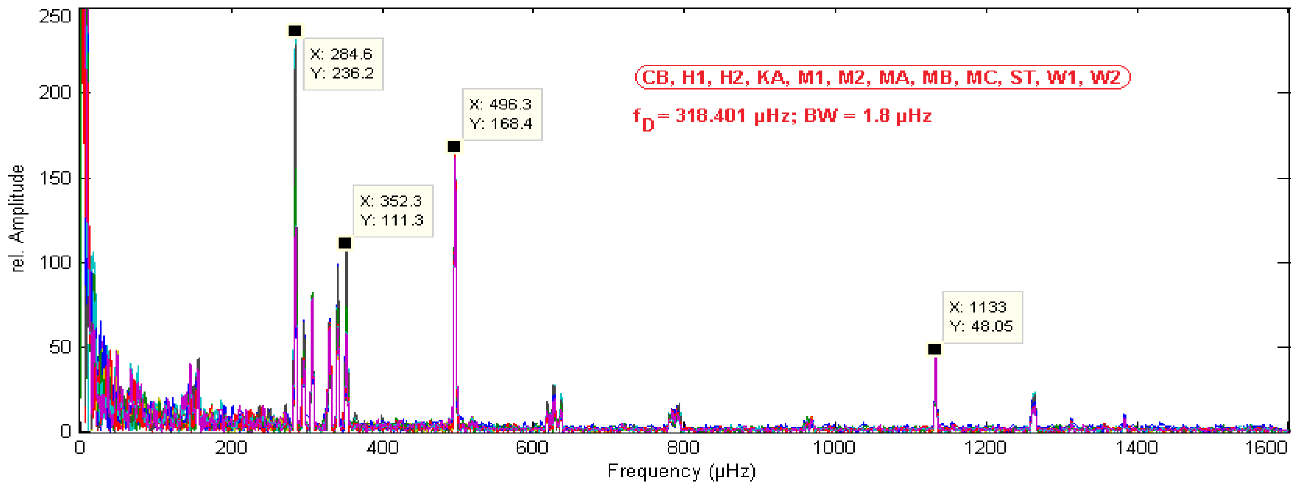
$$f_{2A}-f_{1A}=(1114.634-514.687)\,\mu Hz=2\cdot 299.97\,\mu Hz=2\cdot f_{A}$$

f_A and f_{0S0} do not appear in the spectrum. A rearrangement of these equations reveals that the two solitaires are created by mixing these two frequencies. This process is usually described by the formula

$$\cos(f_A)\cdot\cos(f_{0S0})=½\cdot\cos(f_A-f_{0S0})+½\cdot\cos(f_A+f_{0S0})=½\cdot\cos(f_{1A})+½\cdot\cos(f_{2A})$$

The two solitary spectral lines are heterodynes of different natural resonance frequencies of the earth. It must be emphasized that *only* the frequency f_A (with very low bandwidth) is passed through the filter but does not appear in the spectrum.

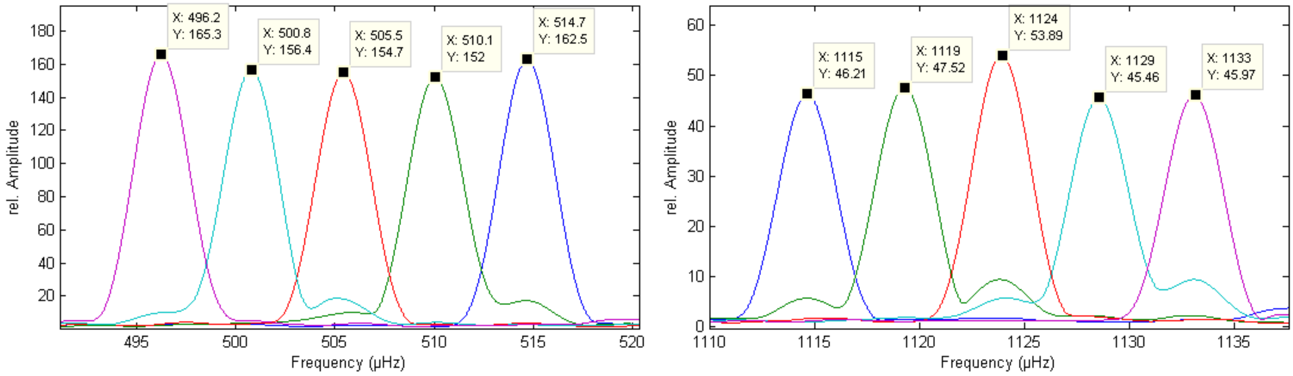
If one chooses a different spectral line like f_D of the ${}_0S_2$ quintet as the center frequency of the filter, all spectral frequencies move slightly. Some heterodynes increase their frequency, others decrease. But the sum and difference of the two solitary lines always leads to the results f_D and f_{0S0} .



In the range between 100 µHz and 1600 µHz, presumably all visible spectral lines are heterodynes and will be discussed in different papers.

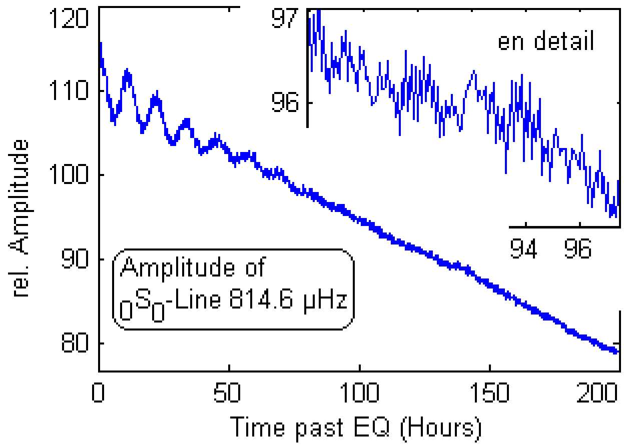
Each frequency mixing - each creation of new frequencies - requires a non-linearity. This can not be caused by a linear working device or process. The program used here is strictly linear and suppresses one of the required frequencies (${}_0S_0$) by the input filter. Therefore, the amplitude modulation of the ${}_0S_2$ quintet with the frequencies f_{1A} and f_{2A} must be done *before* the filter. If any non-linear process can be excluded in the SG and in the calculation program of CORMIN data, they must be sought inside the earth. Somewhere in certain layers of earth, the relationship between pressure and volume is non-linear and the superposition principle applies only approximate. In the field of electromagnetic waves, non-linear phenomena in crystals or the atmosphere were discovered many years ago[3]. In the field of geodynamics, this is the first evidence that either the bulk modulus inside the earth depends on the pressure or somewhere there is a phase transition in solid or liquid matter.

The frequencies of the heterodynes depend on the filter frequency. Changing the center frequency of the Sinc filter results in five different spectra. These are shown in the following pictures with different colors. blue: $f_A = 299.9$ µHz, green: $f_B = 304.6$ µHz, red: $f_C = 309.3$ µHz, turquoise: $f_D = 313.8$ µHz and purple: $f_E = 318.4$ µHz.

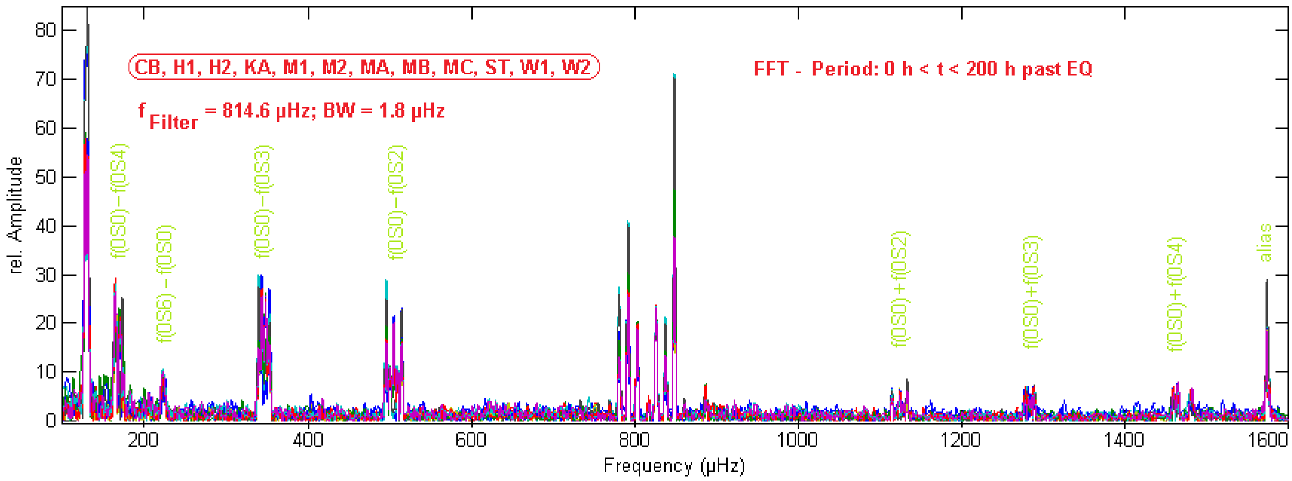


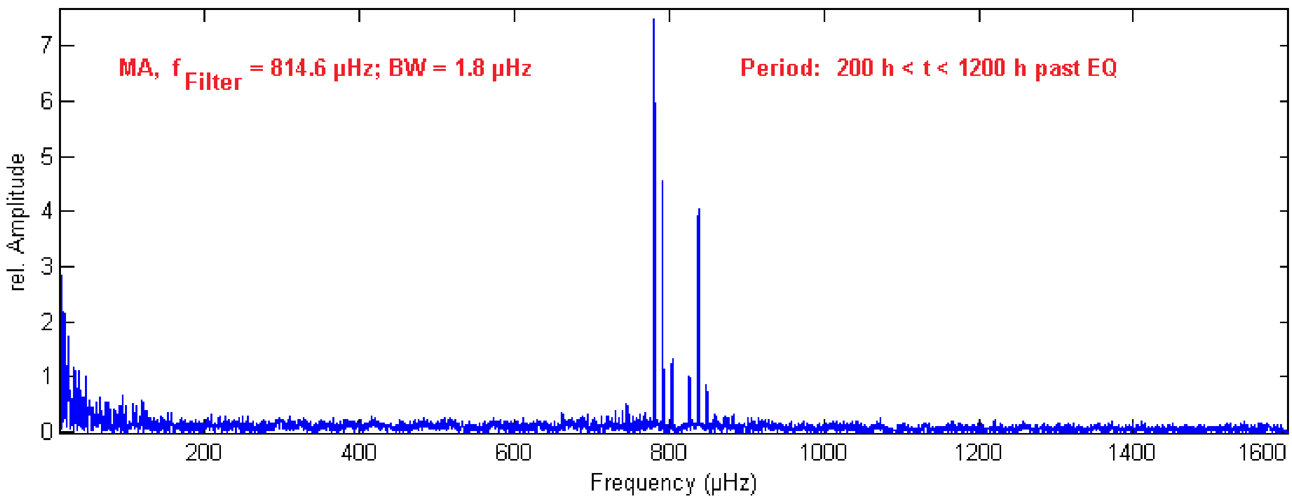
In the images it can be seen that the spectral lines f_B and f_D are considerably stronger frequency-modulated than the other three lines. The shape of the accompanying sidebands are a result of the stronger frequency modulation and are symmetrical to the center frequency. The frequency spacing of the side bands corresponds to the highest modulation frequency $\Delta f \approx 4.5$ µHz of ${}_0S_2$-B and ${}_0S_2$-D[4].

Fast Amplitude Variations of ${}_0S_0$



For the data of each SG-station, the average amplitudes of 2400 periods (length = 2000 minutes) were calculated. The start time of adjacent periods was shifted stepwise by five minutes. The picture shows the amplitude decay of ${}_0S_0$ measured by H1. The results from other stations are very similar. The resulting curve is apparently composed of three components. If one ignores the oscillations during the first 60 hours (f ≈ 23 µHz) and subtracts the slow exponential decay $A = A_0 \cdot e^{-t/T}$ with $T \approx$ 594 hours, a high frequency residual remains. This is *no noise at all* but shows a remarkable spectral composition, independent of the bandwidth. The two spectra below surprise by the symmetry around the filter frequency 814.6 µHz. Almost all spectral lines arrange themselves in groups, whose frequencies correspond to the sum or difference of known resonances of the earth. Mixing requires a *non-linear* component. The symmetrically arranged side bands look like the spectrum of a *double-sideband suppressed-carrier transmission*, a special type of amplitude modulation.

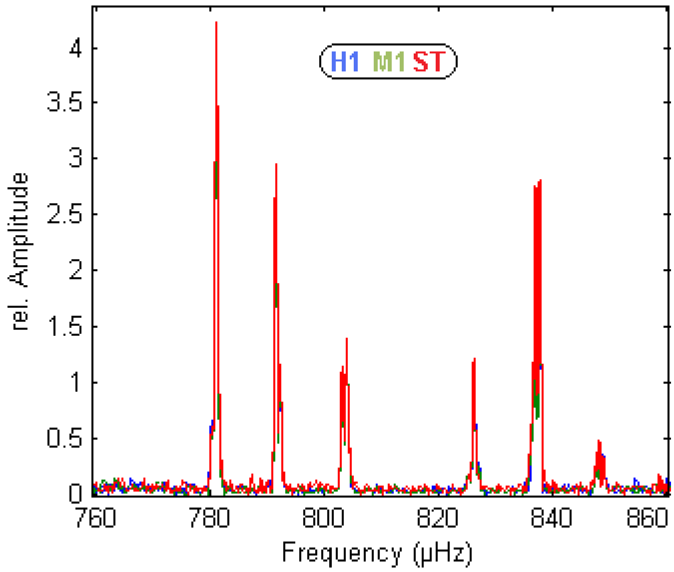




Both spectra above differ in start time and length of the period. During the first 200 hours after the earthquake, most spectral lines are very strong (upper spectrum). 200 hours later, the amplitude of ${}_0S_0$ is still strong, but most of the heterodynes have disappeared in the noise. This confirms their origin because they emerge as a product of two natural frequencies. If one factor becomes zero, the heterodyne disappears. Since the amplitude of the tide is approximately constant, the six central heterodynes reduce the amplitude proportional to that of ${}_0S_0$.

Central Group surrounding 814.6 µHz

A detailed view on the central group (stations H1, M1 and ST) shows a symmetrical arrangement of several spectral lines surrounding the mean frequency 814.658 µHz. In order to achieve a good SNR, the data during the first 100 hours past the earthquake were omitted. The following record length of 1100 hours provides good resolution. The peak frequencies are listed in the left part of the table.

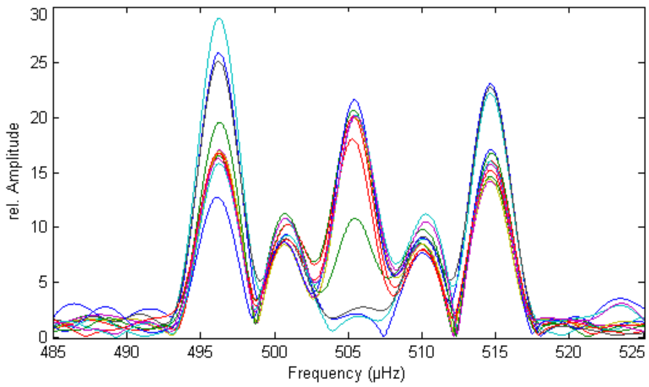


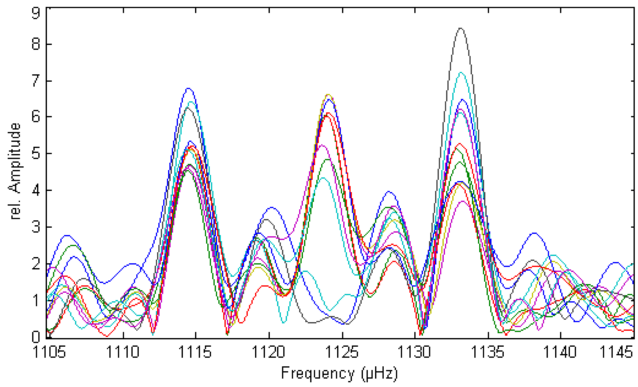
Frequency (µHz)	f-814.658 µHz
780.266	-34.392
781.080	-33.579
791.523	-22.136
792.281	-22.378
803.064	-11.595
803.870	-10.789
826.244	11.586
827.095	12.436
836.554	21.895
837.057	22.399
837.792	23.133
847.739	33.080
848.255	33.597
849.023	34.364

The differences in the right column correspond almost exactly to frequencies of the strong tidal waves, which are generated by the sun and moon.

Cross Modulation ${}_0S_0$ with ${}_0S_2$

The next neighbors of the central group are the quintets of heterodynes near 505 µHz and 1124 µHz, enlarged in the next pictures. The central frequencies are shifted replicas of f_C = 309.3 µHz. The three non-European stations CB, MA and KA measured the central frequency with very low amplitudes[5].



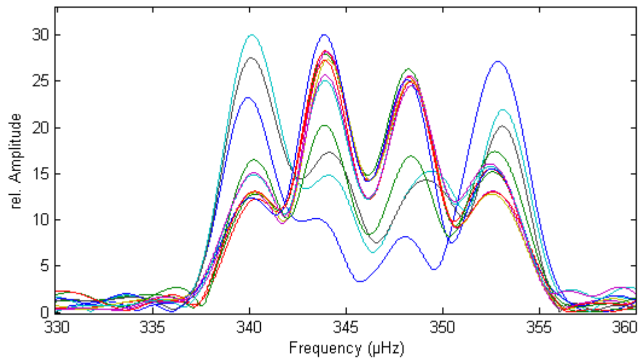


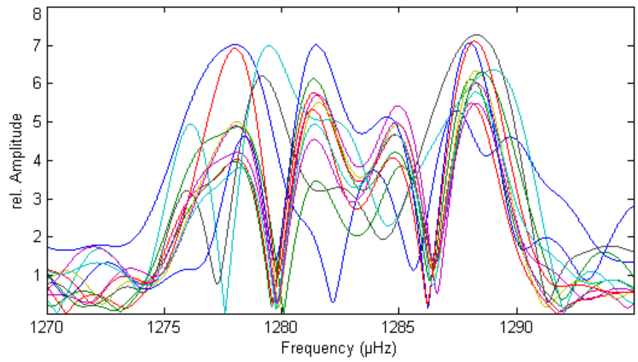
The average values in the left figure are $E_- = 496{,}248$ µHz, $D_- = 500{,}787$ µHz, $C_- = 505{,}454$ µHz, $B_- = 510{,}108$ µHz and $A_- = 514{,}679$ µHz.

The average values in the right figure are $A_+ = 1114{,}578$ µHz, $B_+ = 1119{,}487$ µHz, $C_+ = 1123{,}943$ µHz, $D_+ = 1128{,}451$ µHz and $E_+ = 1133{,}118$ µHz.

Combining these values in the proper order, the jackknife method yields $f_{0S0} = (814.684 \pm 0.032)$ µHz and (with less precision) for the ${}_0S_2$ resonances $f_A = 299.953$ µHz, $f_B = 304.690$ µHz, $f_C = 309.245$ µHz, $f_D = 313.832$ µHz and $f_E = 319.435$ µHz.

Cross Modulation ${}_0S_0$ with ${}_0S_3$





The natural resonance ${}_0S_3$ should split into *seven* frequencies. In the left picture only *four* of them are recognizable (340.157 µHz, 343.940 µHz, 348.339 µHz and 352.771 µHz). In the right picture, the SNR is not sufficient for useful frequency measurements.

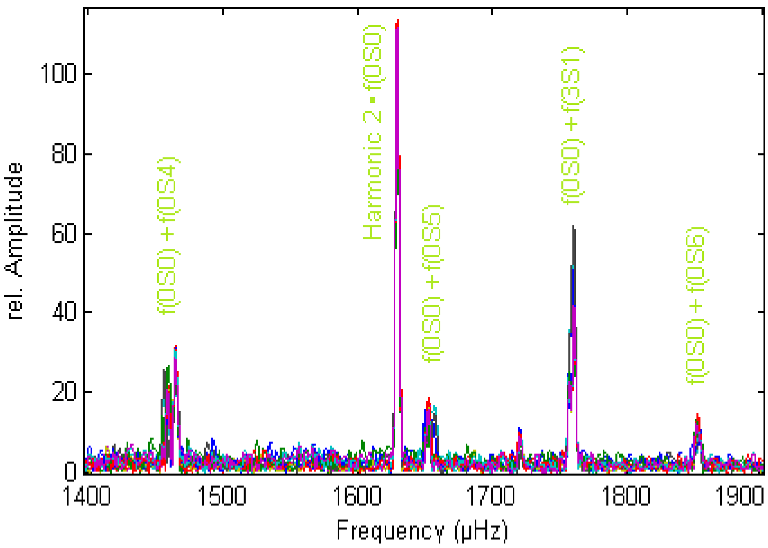
Additional Lines on ${}_0S_0$ Amplitude

Frequency (µHz)	Relative strength	Probable origin
23.2	140	$f_{0S5} - f_{0S0}$
127.9	57	$f_{3S1} - f_{0S0}$
131.2	58	$f_{3S1} - f_{0S0}$
164.5	29	$f_{0S0} - f_{0S4}$
170.3	20	$f_{0S0} - f_{0S4}$
173.9	12	$f_{0S0} - f_{0S4}$
223.6	9	$f_{0S6} - f_{0S0}$
404.7	5	$f_{0S0} - f_{2S1}$
744.96	7	only KA and MA, f_{0S0} - 69.7 µHz, Slichter?

768.5	4	f_{0S0} - 46.2 µHz, Slichter?
816.9	5	??
861.2	4	f_{0S0} + 46.5 µHz, Slichter?
884.43	7	only KA and MA, f_{0S0} + 69.8 µHz, Slichter?
887.0	7	??
1225	5	$f_{0S0} + f_{2S1}$
1455.4	7	$f_{0S0} + f_{0S4}$
1459.2	15	$f_{0S0} + f_{0S4}$
1464.4	30	$f_{0S0} + f_{0S4}$
(~~1572.3~~)	65	Alias from 1760.5 µHz (f_S = 300 s)
(~~1576.3~~)	31	Alias from 1757.3 µHz (f_S = 300 s)
1629.3	114	$2 \cdot f_{0S0}$ (f_S = 240 s)
1652.4	19	$f_{0S0} + f_{0S5}$ (f_S = 240 s)
1720.4	11	??
1757.3	32	$f_{0S0} + f_{3S1}$ (f_S = 240 s)
1760.5	63	$f_{0S0} + f_{3S1}$ (f_S = 240 s)
1852.4	14	$f_{0S0} + f_{0S6}$ (f_S = 240 s)

The application of DFT is prone to aliasing and folding, which is why some spectral lines appear at unexpected positions. The consequent misinterpretations can be avoided when two spectra are compared after switching the sampling frequency. Each spectral line with changed position must be checked and recalculated.

The spectral lines of all the images above were calculated with the increment five minutes, resulting in the Nyquist frequency 1666.67 µHz. All spectral lines near or above this frequency will be misrepresented. After decreasing the step size to four minutes, the two aliases 1572.3 µHz and 1576.3 µHz have disappeared. More important: The spectrum shows that the ${}_0S_0$ oscillation is *not sinusoidal* because the first harmonic can be measured with a surprisingly high amplitude.



Acknowledgments

The underlying data of this examination were measured by a net of about twenty SG distributed over all continents, the data are collected in the Global Geodynamic Project[6]. Thanks to the operators of the GGP stations for the excellent gravity data.

[1] W. Zürn, R. Widmer-Schnidrig, Globale Eigenschwingungen der Erde, Physikalische Blätter, 2002
[2] H. Weidner, Unexplained Resonances in the Gravitation Field of the Earth, 2014, http://vixra.org/abs/1412.0225
[3] https://de.wikipedia.org/wiki/Luxemburgeffekt, https://en.wikipedia.org/wiki/Nonlinear_optics
[4] H. Weidner, https://www.researchgate.net/publication/278627620_Frequency_Modulation_of_0S2-D
[5] H. Weidner, Frequency Modulation of 0S2-C, http://viXra.org/abs/1506.0099
[6] The "Global Geodynamics Project", http://www.eas.slu.edu/GGP/ggphome.html