Open science effort to evaluate the Grand Unified Theory of Classical Physics (GUTCP) of Dr. Randell Mills

Last Update: 28/10/2016 20:12:00

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Z	Number of protons in the nucleus

# V Abbreviations

GUTCP	Grand Unified Theory of Classical Physics
BLP	Brilliant Light Power (Mills company)
NIST	National Institute for Standarnds and Technology
QM	Quantum Mechanics

1 Motivation

I am interested in new energy technologies and search the web for these kinds of news on a quite regular basis. The article I read about a year ago was quite interesting and so I checked the website of a company called brilliantlightpower (BLP). That is how I stumbled over BLP and its founder Dr. Randell Mills. The material on the website was pretty impressive. Especially Dr. Mills book, the grand unified theory of classical physics (GUTCP), looked pretty awesome: 1900 pages of equations and topics ranging from atomic physics over molecular physics to superconductivity and the origin of gravity. The only problem was that I did not understand a single word and could not get what it was all about. Additionally the internet is full of fancy theories and most of them are complete nonsense. So I decided to check BLP from time to time and see if there are any new developments but didn´t take a closer look. In the course of 2016 BLP released new information on their demonstration days but all they could show was a colourful lightshow. Dr. Mills gave a lot of evidence for his theory in the presentations but I am not familiar with spectroscopy and so I did not get the point. More or less the only thing I understood was that graph:

The total bond energies of exact classical solutions of 415 molecules generated by Millsian 1.0 and those from a modern quantum mechanics-based program, Spartan's pre-computed database using 6-31G* basis set at the Hartree-Fock level of theory, were compared to experimental values.
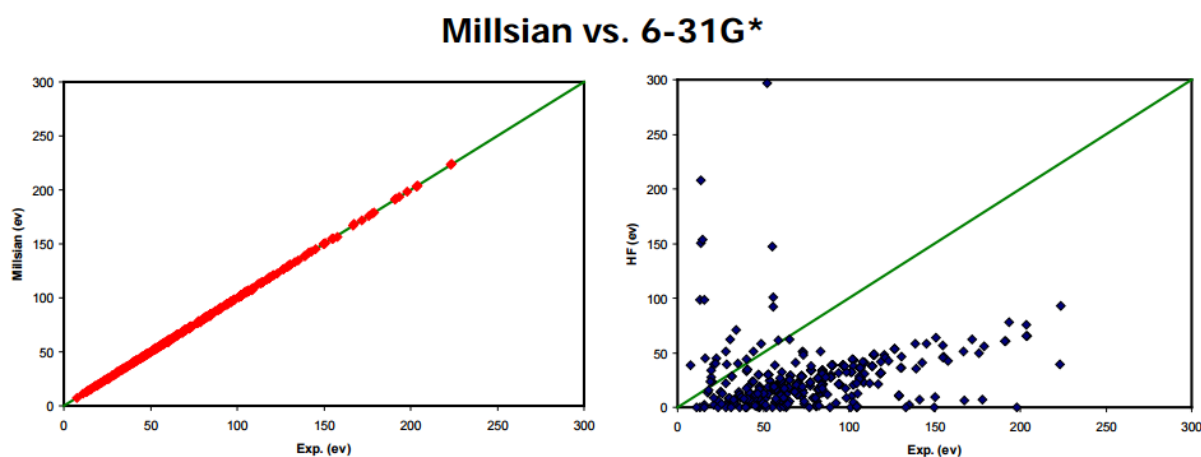
R. L. Mills, B. Holverstott, W. Good, A. Makwana, J. Paulus, "Total Bond Energies of Exact Classical Solutions of Molecules Generated by Millsian 1.0 Compared to Those Computed Using Modern 3-21G and 6-31G* Basis Sets," Phys. Essays 23, 153 (2010); doi: 10.4006/1.3310832

Figure 1: Bond energies of 415 molecules: GUTCP vs. QM

I found this pretty impressive and thought that someone on this planet must have tried to debunk Mills theory as fraud just by showing that Mills faked this graph. If Mills really achieved the accuracy shown in this graph this would be an overwhelming indication for the correctness of his theory. So I searched the web but did not find a single evaluation of these claims. There were some forum threads with the content quality of "Mills is a crackpot, LoL". So this was a dead end.

In the beginning of September 2016 I read that a former student assistant at BLP called Brett Holverstott released a book about Mills and his theory. I saw my chance to finally understand what Mills is all about and read it. It is an awesome book that not only covers the history of GUTCP and BLP but also gives insight into the philosophical and human aspects of science. The most important point of this book for me was the core idea of Mills theory. And it wasn´t even (purely) Mills own work. It was the work of a Professor called Herman Haus Mills met when he was at MIT. It is basically about the question if it is possible to accelerate a charge in a way that it does not radiate energy (if you don´t know what I am talking about read the Wikipedia articles on Bremsstrahlung and the nonradiation condition). Prof. Haus showed that this is possible and Mills took this nonradiation condition and applied it to electrons circling around the nucleus. From this starting point he derived step by step the structure of atoms, molecules, subatomic particles and more or less all known physics. And everything was derived just on the foundation of Newton, Maxwell, special relativity and conservation of energy and spacetime. What impressed me the most was that all these equations were so straight forward that one human being was capable of deriving them (in the timespan of 25 years).

But all the simplicity, beauty and "straight forwardness" of a theory is worthless, if it does not describe reality correctly. On the one hand we have 1900 pages of equations from a single guy who claims that he has surpassed the physics of the last 70 years and on the other hand we have…hmm. What do we have on the other hand? There are some people with a certain reputation on Wikipedia that say that GUTCP is fraud. But these are just pure statements and I did not find a single argument of them that stood longer in the room than one minute.

I was so fascinated by the underlying idea of Mills theory and the possible implications for all mankind that I decided to prove or disprove it on my own. I tried for a few days to understand the underlying math but I failed hard. Then I tried to find somebody skilled in the art to do the math for me but that also failed. Finally I had the idea to apply the salami tactic: if a problem is too big to solve it as a whole cut it in slices. The most promising starting point for me to cut this really huge salami into pieces was the GUTCP volume about the atoms and

molecules. The equations did not look that evil and there is an undisputable experimental database as an independent "ground truth". There are very complex molecules out there and if Mills theory has flaws it would never ever be possible to calculate the structure of these complex molecules correctly. So this little open science effort is all about using Mills equations to compute a growing number of molecules with a growing complexity until it is obvious if Mills theory is able to describe their structure correctly or not. It is about producing solid evidence/data and not just endless blah blah on internet forums.

I invite everyone who is curious, capable of using equations and a calculator and who has some spare time left to join me and contribute. Contribute a calculation script and write a few words about the results in this document so that the discussion about Mills shifts from pointless opinions to solid facts. Upload your results as a response to this forum thread.

1.1 Why to put effort into evaluating GUTCP and not one of the hundreds of interesting theories out there?

I cannot give my opinion on this question in a few short sentences so I am going to use many long ones:

In the early 20th century physicists had a hard time to figure out an atomic model where the positive charge of the nucleus is in the centre with the electron somewhere around it (that is what they found out through experiments). But the basic and really hard questions were: where and what is the electron? If it would stand still it would fall into the massive nucleus. If it would orbit the nucleus it would have been under constant acceleration and would therefor lose energy in form of radiation and then fall into the nucleus. The physicists of that time could not make proper sense out of it and so they took the pragmatic way: they took the observations of the experiments and postulated the properties that fit their models. First Bohr postulated that electrons can just fly around the nucleus on special orbits and electrons on these special orbits don´t radiate. Ten years later Schrödinger postulated that the electron obeys a special wave equation. Don´t get me wrong. There is nothing wrong with postulating physical properties. There are many postulates in physics that we just have to take as given by the gods (Newton, Maxwell,…), but we have to judge them carefully by two and a half measures:

1) How well does my equation/postulate describe the experiments conducted so far? If it explains them all → proceed with 2.
2) How good is the predictive power of my model? What new aspects of our physical reality does my model predict and how do I have to perform new experiments to val-

idate my model? If my models makes some fancy predictions and the validation experiments are positive → proceed with 2.5 (Microsoft Word says that 2.5 is 3).

3) Occam´s razor: if there are two models which perform equally well on points 1) and 2) then take the simplest model with the least variables and assumptions.

And with these two and a half measures things start to get interesting. Now in the backwards view quantum theory is a pretty successful theory. It could explain many phenomena and made some accurate predictions and so points (1) and (2) are well covered. But if a different theory could be found which performs equally well on points (1) and (2) quantum theory would have a really hard time. And that is because of occam´s razor. Many physicists worked tens of years to get rid of the most obvious flaws in QM: They struggled with the interpretation of their equations. They struggled to calculate the simplest parameters of atoms and molecules. They struggled to get rid of the infinitys in their equations. And even today it is a pain in the ass to calculate molecules with the Hartree-Fock algorithm. QM is complicated, it contradicts our physical perception of the world, it is incompatible with special relativity and so on (see GUTCP p. 5 ff. for a few more details). If occam´s razor had another alternative it would cut QM into pieces immediately.

But how could a new theory stand against 70 years of research and experiments? If you would evaluate a new theory in the order (1), (2), (3) there will be no new (and perhaps better) theories in the future of mankind, because a (typically) small group of people would have to go through all major experiments and derive every equation from their new idea. This small group would need to do a great fraction of the work thousands of physicists did over a span of 70 years. That is definitely not possible. That is why I am suggesting a different approach to evaluate a new theory. I call it "justified trust increase" ☺. It is an iterative process and I hope this evaluation of Mills theory is going see many iterations.

1) Judge a new theory by occam´s razor. If it is simpler, uses less postulates and "feels" better take a closer look. ("Justification" step)
2) Take a small subset of the new theory and validate it against experiments.
3) Check if your first impression and the claims of the "inventors" hold while evaluating the small subset of the theory.
4) Proceed iteratively with steps 2 and 3 and build up trust into the new theory. ("Trust Increase" step)
5) If your trust reaches a certain level try to find other interested people to join the "trust increase" process of steps 2) and 3)
6) If your trust and that of the other interested people reaches a new level try to convince people with specific domain knowledge and reputation to look deeper into that

theory → they won´t stop immediately because you are able to counter most of the objections with arguments and experimental proof.

7) Hope that a critical mass builds up to spread out the knowledge into the scientific community.

I got a bit off-topic on the last page so I try to pull us back on the right track. You should take a closer look into GUTCP because:

- Judging GUTCP and QM with occam´s razor gives a great victory for GUTCP. It is a theory which builds upon the well-known laws of electrodynamics, special relativity and conservation of energy. The only additional postulate is the conservation of space time when GUTCP explains what mass is.
- The electron in GUTCP is a real particle with a physical extend. In contrast to the point assumption of QM it has no infinite charge densities etc.
- It is compatible with special relativity.
- …

There are many other points why GUTCP is superior to QM and a list is given in GUTCP p.5 ff. Of course we cannot judge the descriptive (1) and predictive (2) power of GUTCP right now because there are only few evaluations of GUTCP out there. I tried to find the arguments of the critics mentioned on the BLP Wikipedia site. They are more or less non-existent and can be counter argued in a few sentences. Nobody of the nobel laureate critics took a deeper look. The arguments are basically everywhere of the same quality: ”What? Your theory predicts electron orbits below the ground state? Are you nuts?” And that´s it. If anybody knows a real critical evaluation of Mills work please let me know and give a link somewhere here in the document.

If Mills theory is correct the reward for mankind is great:

- Cheap and distributed energy through hydrino power
- The ability to solve the structure of all molecules exactly → this is huge for the development of medicine or material science (perhaps one day Mills theory speeds up the search for medicine that cures your cancer – and yes, I really think that this is an valid argument)
- Explanation what mass is
- Opening space for mankind through anti-gravity (fifth force) ☺ - ok I admit that this is speculative because Mills just performed one experiment so far

Summing it all up, putting effort into this evaluation is worth the trouble. Not just because of the hypothetical "great for whole mankind" propaganda but also because it is great fun ☺. If Mills is successful with his suncell all our work will get surpassed by thousands of physicists within two weeks. But if he screws up again to bring a product to market our effort could be relevant.

1.2 Goals

The goal of this effort is to get the task of evaluating Mills theory to a different level. A level where everyone (my mother excluded) can understand the results and, even better, create the results. The "normal" scientific evaluation process would start with solving the 2D wave equation under the constraint of the nonradiation condition just as Mills started his journey. But how many people on this beautiful planet can do that? In that case we would have to rely on the experts. But experts are humans and the best example is Andreas Rathke, known for his "proof" that GUTCP is wrong (see [Wikipedia](#)). What Wikipedia does not say is that Rathke erroneously used the 3D wave equation and even with this he made a sign error. He explained in an online forum, that he just wrote this paper to prevent ESA to put time and money into the evaluation of Mills. And that are the experts we rely on.

We are lucky that Mills put 25 years of work into this so we can use the more user friendly equations to see if his theory gives valid results.

The goals in condensed form:

- Get the evaluation task to a level where everyone can contribute, understand and interpret the results
- Increasing the number of evaluated molecules, atoms and equations to increase trust into GUTCP, or to show that it is wrong
- Implement the generic equations for all organic molecules (GUTCP p.679 ff.)

The last point is a huge one. If we could accomplish this, the question if GUTCP is far superior to QM regarding the structure of atoms and molecules is definitely answered.

2 Software

There already is software for calculating molecules with Mills equations on the website of Mills [MIS] in the form of excel spreadsheets and the Millisan software package. The excel spreadsheets have the drawbacks that you cannot read the equations properly, you don´t know where the used equations come from and there are many "magical" numbers in them.

The Millisan software seems to be quite powerful, but we cannot look into it to see if there are any cheats and so it is useless for our evaluation purposes.

So the goal is to use a software environment that is usable by people who don´t (or barely) know how to program and that is free of charge. It also has to allow us to follow every calculation line by line and give room for comments. Octave (or the pricy matlab) is great for that purpose. Octave takes the script line by line and interprets/calculates it just like you would do, if you would type in the equations by hand.

2.1 Software to view the script files

If you just want to read the script files with all the equations and comments without having the ability to run the scripts I recommend using the free editor notepad++ [NOTE++]. The script files have the file ending *.m (m for matlab). If you open them with notepad++ the content gets coloured according to the language rules so that you can better distinguish between comments and calculations. It is way better to read the skripts with notepad++ than with a simple text editor.

2.2 Software to use and edit the script files

To run the script files you need Octave or Matlab. Octave is for free and can be downloaded here [OCTA]. For simple calculations no toolboxes are required. If you need more functionality for your calculations (such as symbolic solvers for differentiating/integrating symbolically etc.) you can look through the toolboxes/packages page here.

Just install or unpack (depends on the version you download) Octave and you are good to go. For a tutorial on the first steps with Octave with GUI I point you to this youtube video. This should give you an idea of how to start it and use the scripts. Actually it is pretty easy: In the Octave GUI you have a GUI area called "filebrowser". There you go to the file path of the script files (the *.m files) you unpacked to your hard drive (1). There you should see a file called "MAIN_Start_From_Here.m" (2). Doubleclick to open it in the "editor" part of the Octave GUI (3). There you can press "save and run" (4) and all calculations are processed and printed to the command window (5) which you reach by changing the tab from "Editor" to "Command Window". To see all printed lines you have to press "f" (forward) several times, because Octave just prints as many lines as fit on one Command Window screen. I chose to just print my results to the Command Window, but you can also write it to a file (.csv,.txt) with the file i/o functionality of octave (eg. csvwrite()).
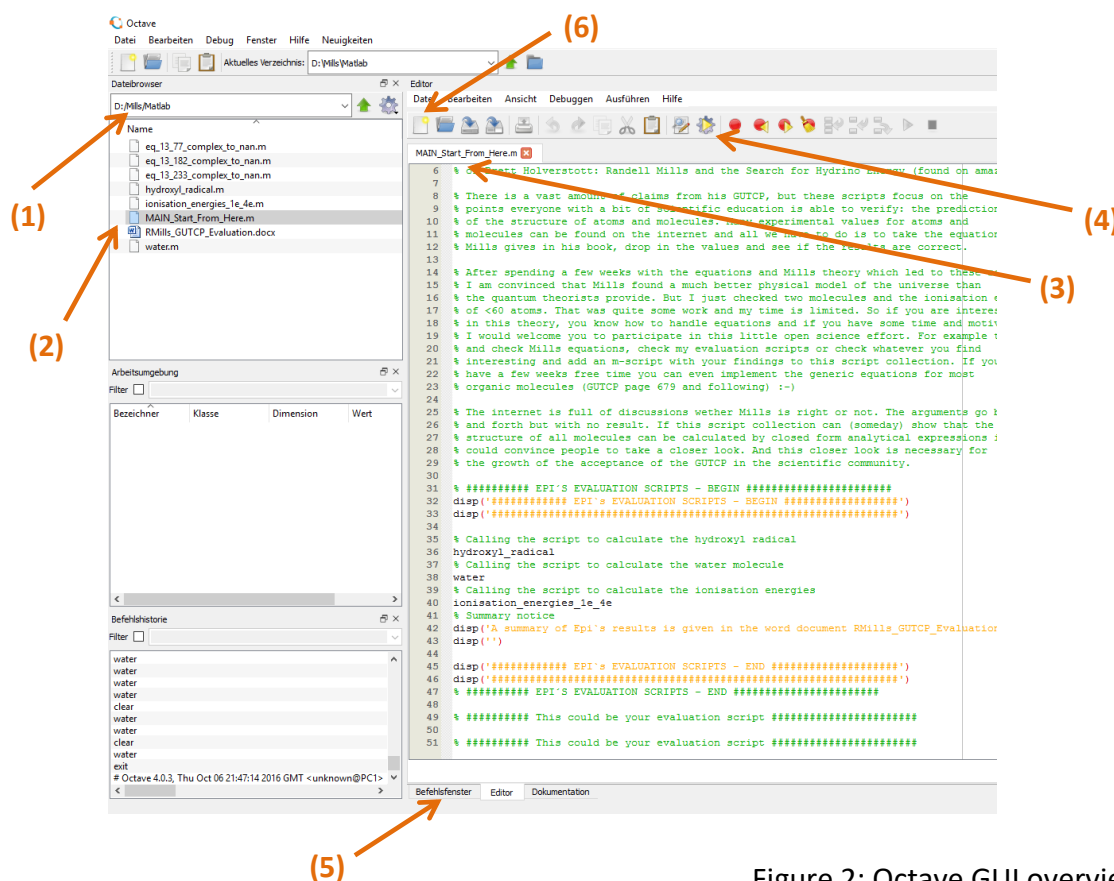
Figure 2: Octave GUI overview

2.3 Creating a new script file

If you want to create your own script file you just have to click on (6) "new script" and save it with the desired name. Than you can start on your own or you copy some of the lines from my script files. The most useful things from my scripts are the physical constants and the code for solving nonlinear equations using the function fzero().

The other way of creating your own script file is to go to the windows explorer, copy and paste one of the script files, rename it, open it in the Octave editor and delete all unnecessary stuff. It is pretty straight forward.

To get most of the results regarding the molecules you don´t need many complex operations. Most equations are covered by basic mathematical operations (+,-,*,/,sqrt(),…). It is more or less as simple as using a calculator.

3 Evaluation results

The evaluation results are grouped by the names/nicknames of the people who contributed. Results can be all sorts of evaluations that aim to prove or disprove GUTCP or analyses of the work of other contributors. The "open science" nature of this evaluation effort asks for a critical and open mind regarding the results obtained here. We (at the moment I ☺) work for free and we are an anonymous bunch of interested people from the internet. So no guarantees are given. Check the results for yourself and report errors and bugs.

3.1 Epi´s contribution

I gave an introduction on my motivation in the first section so I just want to add a few minor things here. In my view the strongest argument for Mills theory is that he just needs fundamental physical constants and equations derived from first principles. So one of my primary goals is to create calculation scripts that only use fundamental physical constants. The problem with that is that Mills uses all kinds of real valued numbers he derived in an earlier chapter. So every time I encountered such a "magical" number I had to find the derivation and implement the equation for that value. There are still some integer values in the equations (factor of 2 or ¾ etc.) but that is totally normal when dealing with physical equations and they cannot be used to "fit" a function to a given value. I still have one real valued number for the vibrational energy of oxygen in my scripts because Mills does not give the exact equation in the "water" chapter. I found the generic equation but I am still not capable of using it, so I decided to use the value from NIST – hopefully I get rid of this value sometime in the future.

Another point I want to mention is that Mills always refers to books or papers when he compares his results with experimental values. I don´t have these books and I am not going to buy/borrow them. Instead, I try to find an online source. This is a practical solution but I don´t get an independent source for experimental values in all cases.

3.1.1 Hydroxyl molecule

The first question I had when I decided to evaluate Mills theory with respect to the structure of molecules was: "Where the fuck should I start?" Over 1000 pages of equations alone in the molecules section of Mills book and constant references to the preceding 200 pages were quite a chunk to chew on. I was lucky to find an evaluation [PAYN] of the hydroxyl molecule on Mills homepage. It is the work of a guy called Philip Payne who got paid by BLP for an "independent" analysis. So my first step became much simpler: take the same molecule

as Payne did and try to repeat his results. That had the benefit not only to evaluate the equations for the hydroxyl molecule but also check one of the many "independent" reports on BLP´s website for validity. The first three evenings I spent on trying to solve a nonlinear equation and progress was non-existent (see 3.1.6). After I cracked that nut it became much easier but progress was still slow. That was because I had the goal to eliminate all "magical" numbers that are neither physical constants nor integers (or integer fractions).

The bottom line is, that I get the same (or nearly the same) results as Payne and Mills get:

- **Ionization energy of oxygen**: 13.606eV (0.00079% rel. error compared to Mills and 0.091% rel. error compared to experimental NIST value.

- **Internuclear distance (O-H):** 9.714e-11m (0.1782% rel. error compared to experimental NIST value)

- **Vibrational energy:** 3701cm^-1 (0.979% rel. error compared to NIST value)

- **Bond dissociation energy:** 4.4248eV (0.3248% rel. error compared to Mills literature value (the value I found had a large standard deviation and I could not make sense of the way temperature comes into play))

3.1.2 Water molecule

I chose water as the second molecule I wanted to take a look at, because it is pretty similar to the hydroxyl molecule but has some different energetic properties because of the added H atom. My expectation was, if Mills theory is derived from first principals as he claims the equations used to calculate the water molecule must be similar to the hydroxyl equations. If Mills had to cheat to get faked values he must have altered the equations to a big extend or at least added some real valued factors. So the task was not only to compare the calculated values to experimental values from independent sources but also have a look if Mills uses the equations in a "consistent manner".

What should I say? He passed both tests. Calculating the water molecule was completely analogous to the hydroxyl molecule. It was in fact that similar that I immediately had the thought of identifying the differences and derive a set of more general equations for a set of atoms and molecules so that one just have to give some values describing the structure of the molecule one wants to calculate and then just pass these values to the general equations. It was a few days later that I stumbled over p. 679ff. where Mills did just that. And he claims that these equations are valid for all organic molecules no matter how complex they are. I consider these generic equations as the "holy grail" of this evaluation effort but understanding and implementing these equations will take more time than I have at the moment.

But what I can say is that the equations given for hydroxyl and water are (at least from the first and second impression) subsets of the generic equations.

- **Internuclear distance:** 9.7139e-11m (Mills gives a literature value of 9.7e-11m – I did not find an online source but it is the same as for the hydroxyl molecule)
- **Bond dissociation energy:** 5.1118eV (the experimental value is 5.1116eV)
- **Bond angle of water:** 106.241° (0.22839% error compared to Mills value which is quite large – perhaps I made a minor error somewhere – the experimental value is hard to determine and varies depending on the source because it is varying with temperature and other surrounding molecules – the ideal (theoretical) quantum mechanical solution is 104.48° according to [Wikipedia](#))

3.1.3 Ionization energies of one and four electron atoms and ions

One important value in Mills framework (and of course in chemistry) is the ionization energy of atoms and ions. While calculating the hydroxyl and the water molecule the ionization energies of H and O are needed. In the chapters for hydroxyl and water these values are given with reference to the chapter where Mills calculates them. The equations are quite interesting, because you have only a single equation for a given number of electrons with the parameter Z (number of protons). So I put a loop around this single equation and increased the number of protons with each iteration by one. The result is a list of ionization energies for one atom and different ions like table 10.2 on p. 218. Mills gives the equations for atoms and ions from one to twenty electrons and I took the two equations for one and four electrons and implemented these.

One electron (1 to 34 protons) and four electrons (5 to 29 protons):

- **I get the same results as Mills** (1 electron: max rel. error for Z=34 is 0.000103%, 4 electrons: max rel. error for Z=29 is 0.00085792%)
- The **agreement between these calculations and the experimental** values found here [IONE] is remarkable and exactly as Mills claims in the corresponding tables
- I compared all values for one electron and some values for four electrons: the experimental **values Mills gives in his GUTCP are exactly the same as in my wikipedia source** – not a single digit was different.
- I could replicate the calculations as well as the experimental values to 100%: **No fitting parameters used – just fundamental constants**

When I first compared my calculations with the experimental values I sat in front of the computer screen staring at it for at least half an hour – I was completely stunned. I then

checked what you need to do in QM to get these results. I found that you have two possibilities to get these values:

1) Take a set of simple equations with fitted parameters for different scenarios as described [here](#).
2) Use the Hartree-Fock algorithm which searches iterativly the energetic equilibrium state of the atom according to QM – that is computational demanding and also uses some "magic" parameters.

Mills equations have fundamental constants only, are computationally simple and give great results in terms of accuracy. Always keep in mind occam´s razor.

3.1.4 Ionization energies of all atoms and ions up to 20 electrons (work in progress)

The ionization energy is a very important parameter for the generic equations Mills gives in his GUTCP. So a first step on the way to a generic calculation framework is a function that calculates these energies. I found that you just need 3 major and a few minor equations to accomplish this. It is three major equations because from 1-20 electrons you have three settings of outer shell electrons: atoms with outer S-orbital, 2p-orbital or 3p-orbital. I hope I have the results by christmas ☺.

3.1.5 Epi´s overall result

I could successfully verify that Mills equations work for hydroxyl, water and the ionization energies of one and four electron atoms/ions exactly as he claims. I did neither find a single false statement nor a calculation error nor a fitted parameter. His remarkable claim that his theory just needs fundamental constants and equations derived from first principles holds as far as my evaluation goes. There also was no part of his derivations where I got suspicious of an abnormal use of farfetched explanations. Up to now using Mills equations "feels" like everything I encountered during my electrical engineering studies.

If his "derivations from first principles" are mathematically correct I cannot judge and for that I am going to wait for a physicist to take a deep look into the guts of GUTCP ☺. But in my view even my few results (6 parameters of 2 molecule + 60 ionization energies) make a strong case for the correctness of Mills underlying assumptions and his mathematical derivations. I cannot imagine a scenario where Mills constructed a false and fraudulent theory just using fundamental constants and getting all these values right by coincidence. That definitly is not plausible. For me there is only one remaining question: is his theory a better descrip-

tion of reality than QM? If we somehow achieve to implement the generic equations for the structure of organic molecules and can show that Mills claims still hold, even this fundamental and huge question is answered to 100% (from my point of view). And the great thing is that we neither need a large hadron collider nor other expensive equipment. We just need to read and understand given equations and hack them into a computer (+ weeks or months of our time *cough*). I think that this is pretty awesome!

3.1.6 Some thoughts on solving nonlinear equations in GUTCP context

As I mentioned earlier I had some trouble to solve a nonlinear equation needed for nearly all molecular calculations. I looked up what algorithms are available in Octave/Matlab and because you can write the equation in the form f(x)=0 the best choice is the function fzero() which searches in a local interval a value for x so that the function f() becomes zero. When I used fzero for the problem at hand it always gave errors and I could not get rid of them. So I looked for other algorithms. I read, that it is possible to convert the problem f(x)=0 to a minimization problem just by taking the square of function f and searching for the local minimum: min f²(x). There are powerful algorithms for that task called "Sequential Quadratic Programming" (SQP). There is a sqp function in octave and so I tried this approach. I did not get an error but the results were far off the real value. I had the feeling that this is because of some numerical problems regarding first and second derivatives used in sqp algorithms. So I imported a symbolic toolbox to octave to symbolically get the first and second derivative of f(x). That worked quite well but the result was still 10% off and I could not increase accuracy. That´s when I thought of the good old plotting of f(x) and searching for the result by hand/eye. At first I could not plot the function because in some intervals the function has complex values – and that is when I realized why fzero() did not work in the first place: it could not handle complex numbers. And so I arrived at my final solution:

1) Write a function f(x) that returns "NotANumber" whenever f(x) becomes complex.
2) Plot f(x) and look for a small interval were f(x) crosses the zero line. Make sure there are no complex values in this interval.
3) Use fzero() for f(x) in this small interval to get the final result.

And that procedure worked like a charm. It also has the advantage, that I have visual confirmation, that there are no other real valued solutions and Mills just took the best fitting one.

3.2 Your contribution

3.2.1 Perhaps the methane molecule (p.524 ff.)…

3.2.2 …or the generic equations for all organic molecules (p. 679 ff.)…

3.2.3 …or the mathematical derivation of the solution of the 2D wave equation under the constraint of the nonradiation condition (hardcore style for physicists)

3.2.4 …

4 Literature and links

[HOL16]   Brett Holverstott: Randell Mills and the Search for Hydrino Energy

[MIS]   http://brilliantlightpower.com/molecular-physics/, oct. 2016

[NOTE++   https://notepad-plus-plus.org/download/v7.1.html, oct. 2016
]

[OCTA]   https://www.gnu.org/software/octave/download.html, oct. 2016

[PAYN]   http://brilliantlightpower.com/wp-content/uploads/papers/PayneOHRadical.pdf
           , oct. 2016

[IONE]   https://en.wikipedia.org/wiki/Ionization_energies_of_the_elements_(data_page)
           #WEL, oct. 2016