Inorganic arrangement crystal beryllium, lithium, selenium and silicon.

Ricardo Gobato*
Secretaria de Estado da Educação do Paraná (SEED/PR),
Av. Maringá, 290, Jardim Dom Bosco,
Londrina/PR, 86060-000, Brasil

Alekssander Gobato
Faculdade Pitágoras Londrina,
Rua Edwy Taques de Araújo, 1100,
Gleba Palhano, Londrina/PR, 86047-500, Brasil

Desire Francine Gobato Fedrigo
Panoramic Residence, Rua Luísa, 388s, ap. 05,
Vila Portuguesa, Tangará da Serra/MT, 78300-000, Brasil

*Corresponding author: ricardogobato@seed.pr.gov.br

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Abstract

The use of inorganic crystals technology has been widely date. Since quartz crystals for watches in the nineteenth century, and common way radio in the early twentieth century, to computer chips with new semiconductor materials. Chemical elements such as beryllium, lithium, selenium and silicon, are widely used in technology. The development of new crystals arising from that arrangement can bring technological advances in several areas of knowledge. The likely difficulty of finding such crystals in nature or synthesized, suggest an advanced study of the subject. A study using computer programs with ab initio method was applied. As a result of the likely molecular structure of the arrangement of a crystal was obtained.
1 Introduction

Within many electronics resonates a crystal that determines a precise rhythm functioning. The clocks, timers, computers, communications equipment and many other tiny devices quartz crystals vibrate accurately ensuring that your circuits work completely orderly and synchronized way. It is difficult to predict what would be electronics today without the presence of these elements. [1]

The use of inorganic crystals technology has been widely date. Since the quartz crystal to the common radio receivers to computer chips with new semiconductor materials. The chemical elements such as Be, Li, Se and Si [2, 3] are widely applied in technology. The use of inorganic crystals new technology has been widely studied. The development of new compounds arising from this arrangement can bring technological advances in several areas of knowledge. The likely difficulty of finding such crystals in nature or synthesized, suggest an advanced study of the subject. A preliminary literature search did not indicate any compounds of said arrangement of these chemical elements. This fact our study can lead to getting new crystals to be used in the materials industry. A study using computer programs with ab initio have been applied. As a result of the likely molecular structure of the arrangement of a crystal was obtained.

1.1 Crystal

A crystal or crystalline solid is a solid material whose constituents, such as atoms, molecules or ions, are arranged in a highly ordered microscopic structure, forming a crystal lattice that extends in all directions. In addition, macroscopic single crystals are usually identifiable by their geometrical shape, consisting of flat faces with specific, characteristic orientations. [4, 5]

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wristwatches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits incorporating them became known as crystal oscillators, but other piezoelectric materials including polycrystalline ceramics are used in similar circuits. [6]

Quartz crystals are manufactured for frequencies from a few tens of kilohertz to hundreds of megahertz. More than two billion crystals are manufactured annually. Most are used for consumer devices such as wristwatches, clocks, radios, computers, and cellphones. Quartz crystals are also found inside test and measurement equipment, such as counters, signal generators, and oscilloscopes. [6]
1.2 History

Piezoelectricity was discovered by Jacques and Pierre Curie in 1880. Paul Langevin first investigated quartz resonators for use in sonar during World War I. The first crystal-controlled oscillator, using a crystal of Rochelle salt, was built in 1917 and patented [7] in 1918 by Alexander M. Nicholson at Bell Telephone Laboratories, although his priority was disputed by Walter Guyton Cady [8]. Cady built the first quartz crystal oscillator in 1921 [9]. Other early innovators in quartz crystal oscillators include G. W. Pierce and Louis Essen.

Electronic-grade quartz crystal is single-crystal silica that is free from all visible defects and has piezoelectric properties that permit its use in electronic circuits for accurate frequency control, timing, and filtration. These uses generate practically all the demand for electronic-grade quartz crystal. A smaller amount of optical-grade quartz crystal is used as windows and lenses in specialized devices including some lasers. [10]

1.3 Crystal: Electrical model

A quartz crystal can be modeled as an electrical network with a low-impedance (series) and a high-impedance (parallel) resonance points spaced closely together. Mathematically (using the Laplace transform), the impedance of this network can be written as:

\[
Z(s) = \frac{1}{\frac{1}{sC_1} + sL_1 + R_1} \left/ \frac{1}{sC_o} \right.
\]

\[
Z(s) = \frac{s^2 + sR_1L_1 + \omega_s^2}{(sC_1)\left[ s^2 + \frac{sR_1L_1}{C_1} + \omega_s^2 \right]}
\]

\[
\omega_s = \frac{1}{\sqrt{L_1 + C_1}}
\]

\[
\omega_s = \sqrt{\frac{C_1 + C_o}{L_1C_1C_o}} = \omega_s = \sqrt{1 + \frac{C_1}{C_o} \approx \omega_s = 1 + \frac{C_1}{2C_o} \quad (C_o \gg C_1)}
\]

where \( s \) is the complex frequency \( (s = j\omega) \), \( \omega_s \) is the series resonant angular frequency, and \( \omega_p \) is the parallel resonant angular frequency.

Adding capacitance across a crystal will cause the (parallel) resonance frequency to decrease. Adding inductance across a crystal will cause the (parallel) resonance frequency to increase. These effects can be used to adjust the frequency at which a crystal oscillates. Crystal manufacturers normally cut and trim their crystals to have a specified resonance frequency with a known “load” capacitance added to the crystal. [5, 6, 11, 12, 13, 14]
2 Ab Initio Methods

Among the various computational methods that simulate or model material, highlight those that do not use any empirical information (this is, one that comes from experimental measurements) on the studied system: from the positions of atoms and interactions between them, these methods are able to solve the quantum problem of interacting atoms and provide the description of the electronic and nuclear system material. Because of this, they are called first principles methods, or ab initio methods. The first such method was the method of Hartree-Fock (HF), still used today day for simulating molecules, clusters of atoms and other quantum systems smaller. In the 70s of the last century it was created methods based on Density Functional Theory (DFT) [15], in order to calculate the microscopic properties of solids: LAPW (Linearized Augmented Plane Wave), LMTO (Linear Muffin Tin Orbital) based methods in pseudopotentials. Used virtually through computer codes, their applications were limited at first to study the simplified and idealized systems. Due to the rapid development of computers in recent decades, these methods have reached such a degree of power efficiency be used to simulate real systems, found in nature or produced in laboratories. Today, they are capable of treating crystals with defects, surfaces, interfaces, etc. biological molecules and to investigate phenomena such as semiconducting, magnetic, superconducing, hyperfine interactions, optical transitions, electronic correlations, etc. [16, 17]

Ab Initio Calculations A rigorous variational calculation on a system involves the following steps:

1. Write down the hamiltonian operator $\hat{H}$ for the system.
2. Select some mathematical functional form as the trial wavefunction. This form should have variable parameters.
3. Minimize

$$E = \frac{\int \psi^* \hat{H} \psi d\tau}{\int \psi^* \psi d\tau}$$

with respect to variations in the parameters. The simple and extended Huckel methods are not rigorous variational calculations. Although they both make use of the secular determinant technique from linear variation theory, no hamiltonian operators are ever written out explicitly and the integrations in $H_{ij}$ are not performed. These are semiempirical methods because they combine the theoretical form with parameters fitted from experimental data.

The term ab initio (from the beginning) is used to describe calculations in which no use is made of experimental data. In an ab initio variational method, all three steps listed above are explicitly performed. In this chapter we describe a certain kind of ab initio calculation called the self-consistent field (SCF) method. This is one of the most commonly encountered types of ab initio calculation for atoms or molecules. We also describe a few popular methods for proceeding beyond the SCF level of approximation.

The SCF method and extensions to it are mathematically and physically con-
siderably more complicated than the one-electron methods already discussed. Thus, one normally does not perform such calculations with pencil and paper, but rather with complicated computer programs. Therefore, in this chapter we are not concerned with how one does such calculations because, in most cases, they are done by acquiring a program written by a group of specialists. Rather we are concerned with a description of the mathematical and physical underpinnings of the method. Because the method is simultaneously complicated and rigorously defined, a special jargon has developed. Terms like “Hartree-Fock”, or “correlation energy” have specific meanings and are pervasive in the literature.

3 The Molecular Hamiltonian

In practice, one usually does not use the complete hamiltonian for an isolated molecular system. The complete hamiltonian includes nuclear and electronic kinetic energy operators, electrostatic interactions between all charged particles, and interactions between all magnetic moments due to spin and orbital motions of nuclei and electrons. Also an accounting for the fact that a moving particle experiences a change in mass due to relativistic effects is included in the complete hamiltonian. The resulting hamiltonian is much too complicated to work with. Usually, relativistic mass effects are ignored, the Born-Oppenheimer approximation is made (to remove nuclear kinetic energy operators), and all magnetic interactions are ignored (except in special cases where we are interested in spin coupling). The resulting hamiltonian for the electronic energy is, in atomic units,

$$\hat{H} = -\frac{1}{2} \sum_{i=1}^{n} \nabla_{i}^{2} + \sum_{\mu=1}^{N} \sum_{i=1}^{n} \frac{Z_{\mu}}{r_{\mu i}} + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{1}{r_{ij}} \quad (6)$$

where $i$ and $j$ are indices for the $n$ electrons and $\mu$ is an index for the $N$ nuclei. The nuclear repulsion energy $V_{nn}$ is

$$V_{nn} = \sum_{\mu=1}^{N-1} \sum_{\upsilon=\mu+1}^{N} \frac{Z_{\mu}Z_{\upsilon}}{r_{\mu \upsilon}} \quad (7)$$

In choosing this hamiltonian, we are in effect electing to seek an energy of an idealized nonexistent systema nonrelativistic system with clamped nuclei and no magnetic moments. If we wish to make a very accurate comparison of our computed results with experimentally measured energies, it is necessary to modify either the experimental or the theoretical numbers to compensate for the omissions in $\hat{H}$. [17]
Figure 1: Representation of the molecular structure of SiSeBeLi$_2$ seed, obtained through computer via Ab Initio calculation method based functional 6.31G, obtained using computer programs HyperChem 7.5 Evaluation [18] and GaussView Version 5 [19].

4 Basic sets

Most of the time spent solving the Roothan-Hall equations numerically is devoted to computing the integrals in the Fock and overlap matrices. Typically so-called Slater-type orbitals (STOs) are used in the basis functions $\phi_{\nu}$, which are inspired by the form of the solutions for the hydrogen atom to first order in the Laguerre polynomials:

$$R_n(r) = 2\zeta^{n+\frac{1}{2}}(2n)!^{-\frac{1}{2}}r^{n-1}e^{\frac{1}{2}\zeta r}$$  \hspace{1cm} (8)

Unfortunately this functional form for the orbitals, while physically inspired, results in computational challenges. What makes the use of STOs challenging is that the integrals involving orbitals sitting on different nuclei can be very difficult to compute.

A simple solution has been to approximate STOs with Gaussian functions instead so-called Gaussian type orbitals (GTOs). That is, one uses multiple Gaussians to approximate the form of the STOs. The advantage of Gaussians is that the product of two Gaussians centered at two different locations is another Gaussian (and can computed analytically) such that the orbital integrals can be computed very fast.

A special notation describes the basis sets used in common ab initio calculations.
STO-3G a minimal basis set in which three Gaussians are used to represent each Slater-type orbital. Useful for quickly computing molecular geometries, but not very accurate.

3-21G three Gaussians are used for the core orbitals. For the valence electrons, a split basis set is employed where two Gaussians are used for a contracted part of the wavefunction and one for the diffuse part. This is important for atoms like oxygen and fluorine where the minimal basis sets don’t allow for the valence orbitals to expand or contract in response to the molecular environment.

6-31G the same as above but with six Gaussians for the core orbitals; more accurate.

6-31G* the same as above but allowing polarization (i.e., distortion) of non-hydrogen orbitals to accommodate asymmetry. This basis set might be considered a standard high accuracy calculation, although it is expensive.

Often, one wants to find an optimal molecular geometry for a molecule. This involves searching nuclear configurations for the one with lowest energy, and thus requires a complete electronic structure determination upon each change of nuclear coordinates. Typically fast, approximate basis sets like STO-3G are first used in this geometry optimization. Then, when the geometry is near the energy minimum, more accurate and expensive basis sets like 6-31G* are employed to refine the calculations. [17, 20]

5 Chemical properties of the compounds of beryllium, lithium, selenium and silicon

5.1 Beryllium

Beryllium is a chemical element with symbol Be and atomic number 4. It is created through stellar nucleosynthesis and is a relatively rare element in the universe. It is a divalent element which occurs naturally only in combination with other elements in minerals. Notable gemstones which contain beryllium include beryl (aquamarine, emerald) and chrysoberyl. As a free element it is a steel-gray, strong, lightweight and brittle alkaline earth metal. [21]

Beryllium improves many physical properties when added as an alloying element to aluminium, copper (notably the alloy beryllium copper), iron and nickel [22]. Tools made of beryllium copper alloys are strong and hard and do not create sparks when they strike a steel surface. In structural applications, the combination of high flexural rigidity, thermal stability, thermal conductivity and low density (1.85 times that of water) make beryllium metal a desirable aerospace material for aircraft components, missiles, spacecraft, and satellites [22]. Because of its low density and atomic mass, beryllium is relatively transparent to X-rays and other forms of ionizing radiation; therefore, it is the most common window material for X-ray equipment and components of particle physics experiments [22]. The high thermal conductivities of beryllium and beryllium oxide have led to their use in thermal management applications.
The commercial use of beryllium requires the use of appropriate dust control equipment and industrial controls at all times because of the toxicity of inhaled beryllium-containing dusts that can cause a chronic life-threatening allergic disease in some people called berylliosis. [23]

5.2 Lithium

Lithium (from Greek: λιθος lithos, “stone”) is a chemical element with symbol Li and atomic number 3. It is a soft, silver-white metal belonging to the alkali metal group of chemical elements. Under standard conditions it is the lightest metal and the least dense solid element. Like all alkali metals, lithium is highly reactive and flammable. For this reason, it is typically stored in mineral oil. When cut open, it exhibits a metallic luster, but contact with moist air corrodes the surface quickly to a dull silvery gray, then black tarnish. Because of its high reactivity, lithium never occurs freely in nature, and instead, only appears in compounds, which are usually ionic. Lithium occurs in a number of pegmatitic minerals, but due to its solubility as an ion, is present in ocean water and is commonly obtained from brines and clays. On a commercial scale, lithium is isolated electrolytically from a mixture of lithium chloride and potassium chloride. [24]

The nuclei of lithium verge on instability, since the two stable lithium isotopes found in nature have among the lowest binding energies per nucleon of all stable nuclides. Because of its relative nuclear instability, lithium is less common in the solar system than 25 of the first 32 chemical elements even though the nuclei are very light in atomic weight [25]. For related reasons, lithium has important links to nuclear physics. The transmutation of lithium atoms to helium in 1932 was the first fully man-made nuclear reaction, and lithium-6 deuteride serves as a fusion fuel in staged thermonuclear weapons. [26]

Lithium and its compounds have several industrial applications, including heat-resistant glass and ceramics, lithium grease lubricants, flux additives for iron, steel and aluminium production, lithium batteries and lithium-ion batteries. These uses consume more than three quarters of lithium production.

Trace amounts of lithium are present in all organisms. The element serves no apparent vital biological function, since animals and plants survive in good health without it. Non-vital functions have not been ruled out. The lithium ion Li$^+$ administered as any of several lithium salts has proved to be useful as a mood-stabilizing drug in the treatment of bipolar disorder, due to neurological effects of the ion in the human body. [24]

5.3 Selenium

Selenium is a chemical element with symbol Se and atomic number 34. It is a nonmetal with properties that are intermediate between those of its periodic table column-adjacent chalcogen elements sulfur and tellurium. It rarely occurs in its elemental state in nature, or as pure ore compounds. Selenium (Greek σελήνη selene meaning “Moon”) was discovered in 1817 by Jöns Jacob
Berzelius, who noted the similarity of the new element to the previously known tellurium (named for the Earth). [27]

Selenium is found impurely in metal sulfide ores, copper where it partially replaces the sulfur. Commercially, selenium is produced as a byproduct in the refining of these ores, most often during production. Minerals that are pure selenide or selenate compounds are known, but are rare. The chief commercial uses for selenium today are in glassmaking and in pigments. Selenium is a semiconductor and is used in photocells. Uses in electronics, once important, have been mostly supplanted by silicon semiconductor devices. Selenium continues to be used in a few types of DC power surge protectors and one type of fluorescent quantum dot. [27]

Selenium salts are toxic in large amounts, but trace amounts are necessary for cellular function in many organisms, including all animals, and is an ingredient in many multi-vitamins and other dietary supplements, including infant formula. Selenium is a component of the antioxidant enzymes glutathione peroxidase and thioredoxin reductase (which indirectly reduce certain oxidized molecules in animals and some plants). It is also found in three deiodinase enzymes, which convert one thyroid hormone to another. Selenium requirements in plants differ by species, with some plants requiring relatively large amounts, and others apparently requiring none. [28]

5.4 Silicon

Silicon is a chemical element with symbol Si and atomic number 14. It is a tetravalent metalloid, more reactive than germanium, the metalloid directly below it in the table. Controversy about silicon’s character dates to its discovery; it was first prepared and characterized in pure form in 1823. In 1808, it was given the name silicium (from Latin: *silex*, hard stone or flint), with an *-ium* word-ending to suggest a metal, a name which the element retains in several non-English languages. However, its final English name, first suggested in 1817, reflects the more physically similar elements carbon and boron. [29]

Silicon is the eighth most common element in the universe by mass, but very rarely occurs as the pure free element in nature. It is most widely distributed in dusts, sands, planetoids, and planets as various forms of silicon dioxide (silica) or silicates. Over 90% of the Earth’s crust is composed of silicate minerals, making silicon the second most abundant element in the Earth’s crust (about 28% by mass) after oxygen. [30]

Most silicon is used commercially without being separated, and indeed often with little processing of compounds from nature. These include direct industrial building-use of clays, silica sand and stone. Silicate goes into Portland cement for mortar and stucco, and when combined with silica sand and gravel, to make concrete. Silicates are also in whiteware ceramics such as porcelain, and in traditional quartz-based soda-lime glass and many other specialty glasses. More modern silicon compounds such as silicon carbide form abrasives and high-strength ceramics. Silicon is the basis of the widely used synthetic polymers called silicones. [29]
Elemental silicon also has a large impact on the modern world economy. Although most free silicon is used in the steel refining, aluminium-casting, and fine chemical industries (often to make fumed silica), the relatively small portion of very highly purified silicon that is used in semiconductor electronics (<10%) is perhaps even more critical. Because of wide use of silicon in integrated circuits, the basis of most computers, a great deal of modern technology depends on it. [29]

Silicon is an essential element in biology, although only tiny traces of it appear to be required by animals [31]. However, various sea sponges as well as microorganisms like diatoms and radiolaria secrete skeletal structures made of silica. Silica is often deposited in plant tissues, such as in the bark and wood of Chrysobalanaceae and the silica cells and silicified trichomes of Cannabis sativa, horsetails and many grasses. [32]

6 Molecular parameters of the atoms of the molecule SiSeBeLi₂.

Table 1. Data SiSeBeLi₂ seed molecule

| Chemical formula | SiSeBeLi₂ |
|------------------|-----------|
| Atomic weight    | 129.94 g/mol |
| Crystal system   | triclinic |
| Density          | 215.757 g/cm³ |
| Type of formula  | NOPQ2 |
| Wyckoff sequence | a5 |
Table 2. Molecular parameters of the atoms of the molecule SiSeBeLi$_2$.

| Atom | NA | NB | NC | Bond ° | Angle ° | Dihedral ° | X(Å)   | Y(Å)   | Z(Å)   |
|------|----|----|----|--------|---------|------------|--------|--------|--------|
| Si   |     | 0  | 0  | -0.3790000 | -1.0800000 | 1.7070000 |        |        |        |
| Se   | 1  |    |    | 3.0272777 | -0.6710000 | 0.6810000 | -0.7380000 |        |        |        |
| Be   | 2  | 1  |    | 1.8506712 | 40.6512698 | -1.6610000 | -0.5390000 | 0.2400000 |        |        |
| Li   | 1  | 3  | 2  | 2.4351417 | 69.0527075 | 53.4172985 | -0.6240000 | 1.3410000 | 1.6140000 |        |        |
| Li   | 3  | 2  | 1  | 2.4492640 | 68.7308859 | -58.1835086 | 0.4120000 | -1.5420000 | -0.5940000 |        |        |
7 Discussions

The Figure 1 represents the molecular structure of SiSeBeLi$_2$ seed, obtained through computer via Ab Initio calculation method based functional 6.31G [17, 20], obtained using computer programs HyperChem 7.5 Evaluation [18] and GaussView Version 5 software [19]. The Figure 2 represents of the crystalline structure obtained with SiSeBeLi$_2$ seed in likely arrangement, obtained using the GaussView Version 5 software [19]. The Figure 2 represents of the crystalline structure obtained with SiSeBeLi$_2$ seed in likely arrangement. The Figures 3, 4 and 5 represents of the molecular structure of the crystal likely Be$_{18}$Li$_{40}$Se$_{16}$Si$_{12}$. The Figures 6 and 7 represents of the molecular structure of the crystal likely Be$_{18}$HLi$_{36}$Se$_{28}$Si$_{15}$.

8 Conclusions

As a result of the likely molecular structure of the arrangement of a crystal was obtained. The techniques of micro-crushing and conoscopic [33] analysis can lead to evidence and obtaining such crystals.

References

[1] Newton C. Braga. Como funciona o cristal na eletrônica (art423). Instituto Newton C. Braga, July 2015.
[2] R. E. Newnham. Properties of materials. Anisotropy, Symmetry, Structure. New York, 2005.
[3] A. J. Hall C. D. Gribble. A Practical Introduction to Optical Mineralogy. 1985.
[4] Crystal. Wikipedia, the free encyclopedia, July 2015.
[5] Robert J. Matthys. Crystal Oscillator Circuits. Malabar, Florida 32950, 1992.
[6] Crystal oscillator. Wikipedia, the free encyclopedia, July 2015.
[7] Alexander M. Nicholson. Generating and transmitting electric currents.
[8] Virgil E. Bottom. A history of the quartz crystal industry in the usa. Proc. 35th Frequency Control Symp. IEEE., 1981.
[9] Warren Marrison. The evolution of the quartz crystal clock. Bell System Technical Journal (AT&T), (27):510588, 1948.
[10] Gordon T. Austin. Quartz crystal. minerals.usgs.gov.
[11] John R. Vig. *Quartz Crystal - Resonators and Oscillators*. U.S. Army Communications-Electronics Command, Attn: AMSEL-RD-C2-PT, Fort Monmouth, NJ 07703, USA, January 2000.

[12] Texas Instruments. An-1939 crystal based oscillator design with the lmk04000 family. *Texas Instruments Incorporated, Application Report*, April 2013.

[13] Steven Bible. Crystal oscillator basics and crystal selection for rfpic tm and picmicro devices. *Microchip Technology Inc.*, (AN826):DS00826A, 2002.

[14] Digital Electronics Autumn. *Digital Electronics Autumn, Crystal Oscillators*. 4.1-4b7 edition, 2014.

[15] R. G. Parr and W. Yang. *Density Functional Theory*. 1989.

[16] Milan Lalic. Métodos de primeiros princípios. Universidade Federal de Sergipe, July 2015.

[17] John P. Lowe and Kirk A. Peterson. *Quantum Chemistry*. Elsevier Inc., third edition edition, 30 Corporate Drive, Suite 400, Burlington, MA 01803, USA; 525 B Street, Suite 1900, San Diego, CA 92101-4495, USA; 84 Theobalds Road, London WC1X 8RR, UK. 2006.

[18] Hyperchem.7.5 Evaluation. Computational chemistry, 2003.

[19] Todd Keith Roy Dennington and John Millam. Gaussview, version 5, 2009.

[20] M. S. Shell. Ab initio and electronic structure methods, che210d, October 2009.

[21] Beryllium. Wikipedia, the free encyclopedia, July 2015.

[22] Concise encyclopedia chemistry. trans. rev. Eagleson, Mary. Berlin: Walter de Gruyter, 1994.

[23] Ralph Puchta. A brighter beryllium. *Nature Chemistry*, 3 (5): 416(5):416, 2011.

[24] Lithium. Wikipedia, the free encyclopedia, July 2015.

[25] Katharina Lodders. Solar system abundances and condensation temperatures of the elements. *The Astrophysical Journal (The American Astronomical Society)*, 591(2):12201247., July 10 2003. Bibcode:2003ApJ...591.1220L.

[26] Federation of American Scientists. Nuclear weapon design. fas.org, 10 1998.

[27] Selenium. Wikipedia, the free encyclopedia, July 2015.

[28] George Ruyle. Poisonous plants on arizona rangelands. *The University of Arizona*, 05 2009.
[29] Silicon. Wikipedia, the free encyclopedia, July 2015.

[30] R. Nave. Abundances of the elements in the earth’s crust. Georgia State University.

[31] Forrest H. Nielsen. Ultratrace elements in nutrition. *Annual Review of Nutrition*, (4):2141, 1984.

[32] Elizabeth G. Cutter. *Plant Anatomy. Part 1 Cells and Tissues*. ISBN 0 7131 2639 6. 2nd ed. edition, 1978.

[33] A. Zanardo T. M. B. Galembeck A. J. R. Nardy, F. B. Machado. Mineralogia Óptica de cristais transparentes. parte prática. Unesp: Cultura Acadêmica, 2010.

[34] J. A. Chisholm P. R. Edgington P. McCabe E.Pidcock L. Rodriguez-Monge R. Taylor J. van de Streek C. F. Macrae, I. J. Bruno and P. A. Wood. Mercury csd 2.0 - new features for the visualization and investigation of crystal structures. *J. Appl. Cryst*, 41:466–470, 2008.

[35] David C Lonie Tim Vandermeersch Eva Zurek Marcus D Hanwell, Donald E Curtis and Geoffrey R Hutchison. Avogadro: An advanced semantic chemical editor, visualization, and analysis platform. *Journal of Cheminformatics*, (4):17, 2012.

9 Figures and PDB files

9.1 .pdb file of Figure 1

SiSeBeLi₂

HEADER CSD ENTRY SiSeBeLi₂ SEED
AUTHOR GENERATED BY OPEN BABEL 2.3.2 [34] SiSeBeLi₂ CRYST1
1.0000 1.0000 1.0000 90.00 90.00 90.00
SCALE1 1.000000 0.000000 0.000000 0.000000
SCALE2 0.000000 1.000000 0.000000 0.000000
SCALE3 0.000000 0.000000 1.000000 0.000000
HETATM 1 Si UNK 1 -0.451 -1.255 1.850 1.00 0.00 Si
HETATM 2 Se UNK 2 -0.695 0.755 -0.890 1.00 0.00 Se
HETATM 3 Be UNK 3 -1.719 -0.555 0.321 1.00 0.00 Be
HETATM 4 Li UNK 4 -0.561 1.384 1.567 1.00 0.00 Li
HETATM 5 Li UNK 5 0.503 -1.470 -0.620 1.00 0.00 Li
CONECT 1 2 3
CONECT 2 1 3 4 5
CONECT 3 1 2
CONECT 4 2
CONECT 5 2
MASTER 0 0 0 0 0 0 3 5 0 5 0
END
Figure 2: Representation of the crystalline structure obtained with SiSeBeLi$_2$ seed in likely arrangement, obtained using the GaussView Version 5 software [19].
Figure 3: Representation of the molecular structure of the crystal likely $\text{Si}_2\text{Se}_3\text{Be}_3\text{Li}_6$ obtained using the *Mercury - Crystal Structure Visualisation* [34] software, with SiSeBeLi$_2$ seed in likely arrangement.
Figure 4: Representation of the molecular structure of the crystal likely \( \text{Be}_{18}\text{Li}_{40}\text{Se}_{16}\text{Si}_{12} \) obtained using the *Mercury - Crystal Structure Visualisation* [34] software, with \( \text{Si}_{2}\text{Se}_{3}\text{Be}_{3}\text{Li}_{6} \) seed in likely arrangement, with Molecular weight: 2,040.245 g/mol, Chemical formula: \( \text{Be}_{18}\text{Li}_{40}\text{Se}_{16}\text{Si}_{12} \); Number of Atoms: 86; Number of Bonds: 275 and Number of Residues: 5.
Figure 5: Representation of the molecular structure of the crystal likely Be$_{18}$Li$_{40}$Se$_{16}$Si$_{12}$ obtained using the Avogadro: An advanced semantic chemical editor, visualization, and analysis platform [35].
Figure 6: Representation of the molecular structure of the crystal likely Be$_{18}$HLi$_{36}$Se$_{28}$Si$_{15}$ obtained using the *Mercury - Crystal Structure Visualisation* software [34], with Molecular weight 3,045.266 g/mol; Chemical formula: Be$_{18}$HLi$_{36}$Se$_{28}$Si$_{15}$; Number of Atoms: 97; Number of Bonds: 291 and Number of Residues: 5.
Figure 7: Representation of the molecular structure of the crystal likely Be\textsubscript{18}HLi\textsubscript{36}Se\textsubscript{28}Si\textsubscript{15} obtained using the Avogadro: An advanced semantic chemical editor, visualization, and analysis platform software [35].

9.2 .pdb file of Figures 4 and 5

Be\textsubscript{18}Li\textsubscript{40}Se\textsubscript{16}Si\textsubscript{12}

HEADER CSD ENTRY Be\textsubscript{18}HLi\textsubscript{40}Se\textsubscript{16}Si\textsubscript{12}
AUTHOR GENERATED BY OPEN BABEL 2.3.2 [34] Be\textsubscript{18}Li\textsubscript{40}Se\textsubscript{16}Si\textsubscript{12}
CRYS1 4.243 4.243 40.000 90.00 90.00 60.00 P1 1
HETATM 1 LI LIG 1 -2.848 4.788 -4.380 1.00 0.00 Li
HETATM 2 LI LIG 1 -4.969 1.113 -4.380 1.00 0.00 Li
HETATM 3 LI LIG 1 -4.969 3.563 -2.648 1.00 0.00 Li
HETATM 4 LI LIG 1 -1.375 3.393 -3.816 1.00 0.00 Li
HETATM 5 SE LIG 1 -1.025 4.148 -3.943 1.00 0.00 Se
HETATM 6 LI LIG 1 1.395 4.788 -4.380 1.00 0.00 Li
HETATM 7 LI LIG 1 -3.497 -0.281 -3.816 1.00 0.00 Li
HETATM 8 SI LIG 1 -1.553 3.432 -3.381 1.00 0.00 Si2-
HETATM 9 SE LIG 1 -3.147 0.474 -3.943 1.00 0.00 Se
HETATM 10 BE LIG 1 -2.944 2.415 -4.592 1.00 0.00 Be
HETATM 11 LI LIG 1 -3.497 2.168 -2.084 1.00 0.00 Li
HETATM 12 LI LIG 1 -0.726 1.113 -4.380 1.00 0.00 Li
HETATM 13 SE LIG 1 -3.147 2.923 -2.211 1.00 0.00 Se
HETATM 14 BE LIG 1 -2.944 4.865 -2.860 1.00 0.00 Be
HETATM 15 LI LIG 1 -3.497 4.618 -0.352 1.00 0.00 Li
HETATM 16 LI LIG 1 -0.726 3.563 -2.648 1.00 0.00 Li
HETATM 17 SI LIG 1 -3.674 -0.242 -3.381 1.00 0.00 Si2-
HETATM 18 LI LIG 1 -2.848 -2.561 -4.380 1.00 0.00 Li
HETATM 19 SI LIG 1 -3.674 2.207 -1.649 1.00 0.00 Si2-
HETATM 20 LI LIG 1 -2.848 -0.111 -2.648 1.00 0.00 Li
HETATM 21 LI LIG 1 -2.848 2.338 -0.916 1.00 0.00 Li
HETATM 22 LI LIG 1 -4.969 -3.786 -2.648 1.00 0.00 Li
HETATM 23 LI LIG 1 -4.969 -1.336 -0.916 1.00 0.00 Li
HETATM 24 LI LIG 1 2.867 3.393 -3.816 1.00 0.00 Li
HETATM 25 SE LIG 1 3.217 4.148 -3.943 1.00 0.00 Se
HETATM 26 LI LIG 1 0.746 -0.281 -3.816 1.00 0.00 Li
HETATM 27 SI LIG 1 2.690 3.432 -3.381 1.00 0.00 Si2-
HETATM 28 SE LIG 1 1.096 0.474 -3.943 1.00 0.00 Se
HETATM 29 BE LIG 1 1.298 2.415 -4.592 1.00 0.00 Be
HETATM 30 LI LIG 1 0.746 2.168 -2.084 1.00 0.00 Li
HETATM 31 LI LIG 1 3.516 1.113 -4.380 1.00 0.00 Li
HETATM 32 SI LIG 1 2.690 3.432 -3.381 1.00 0.00 Si2-
HETATM 33 BE LIG 1 1.298 4.865 -2.860 1.00 0.00 Be
HETATM 34 SI LIG 1 0.569 4.618 -0.352 1.00 0.00 Li
HETATM 35 SI LIG 1 3.516 3.563 -2.648 1.00 0.00 Li
HETATM 36 SI LIG 1 -1.375 -3.956 -3.816 1.00 0.00 Li
HETATM 37 SI LIG 1 0.569 -0.242 -3.381 1.00 0.00 Si2-
HETATM 38 SE LIG 1 -1.025 -3.201 -3.943 1.00 0.00 Se
HETATM 39 BE LIG 1 -0.823 -1.259 -4.592 1.00 0.00 Be
HETATM 40 LI LIG 1 -1.375 -1.506 -2.084 1.00 0.00 Li
HETATM 41 LI LIG 1 1.395 2.338 -0.916 1.00 0.00 Li
HETATM 42 SI LIG 1 0.569 2.207 -1.649 1.00 0.00 Si2-
HETATM 43 SE LIG 1 -1.025 -0.751 -2.211 1.00 0.00 Se
HETATM 44 BE LIG 1 -0.823 1.190 -2.860 1.00 0.00 Be
HETATM 45 LI LIG 1 -1.375 0.943 -0.352 1.00 0.00 Li
HETATM 46 SI LIG 1 1.395 -0.111 -2.648 1.00 0.00 Li
HETATM 47 SE LIG 1 -1.025 1.698 -0.479 1.00 0.00 Se
HETATM 48 BE LIG 1 -0.823 3.640 -1.128 1.00 0.00 Be
HETATM 49 LI LIG 1 1.395 2.338 -0.916 1.00 0.00 Li
HETATM 50 SI LIG 1 -1.553 -3.917 -3.381 1.00 0.00 Si2-
HETATM 51 BE LIG 1 -2.944 -4.933 -4.592 1.00 0.00 Be
HETATM 52 SI LIG 1 -1.553 -1.467 -1.649 1.00 0.00 Si2-
HETATM 53 SE LIG 1 -3.147 -4.425 -2.211 1.00 0.00 Se
HETATM 54 BE LIG 1 -2.944 -2.484 -2.860 1.00 0.00 Be
HETATM 55 LI LIG 1 -3.497 -2.731 -0.352 1.00 0.00 Li
HETATM 56 SI LIG 1 -0.726 -3.786 -2.648 1.00 0.00 Li
HETATM 57 SE LIG 1 -3.147 -1.976 -0.479 1.00 0.00 Se
HETATM 58 BE LIG 1 -2.944 -0.034 -1.128 1.00 0.00 Be
HETATM 59 LI LIG 1 -0.726 -1.336 -0.916 1.00 0.00 Li
HETATM 60 SI LIG 1 4.989 -0.281 -3.816 1.00 0.00 Li
HETATM 61 LI LIG 1 4.989 2.168 -2.084 1.00 0.00 Li
HETATM 62 SI LIG 1 4.989 4.618 -0.352 1.00 0.00 Li
HETATM 63 LI LIG 1 2.867 -3.956 -3.816 1.00 0.00 Li
HETATM 64 SI LIG 1 4.811 -0.242 -3.381 1.00 0.00 Si2-
HETATM 65 SE LIG 1 3.217 -3.201 -3.943 1.00 0.00 Se
HETATM 66 BE LIG 1 3.420 -1.259 -4.592 1.00 0.00 Be
HETATM 67 LI LIG 1 2.867 -1.506 -2.084 1.00 0.00 Li
HETATM 68 SI LIG 1 4.811 2.207 -1.649 1.00 0.00 Si2-
HETATM 69 SE LIG 1 3.217 -0.751 -2.211 1.00 0.00 Se
HETATM 70 BE LIG 1 3.420 1.190 -2.860 1.00 0.00 Be
HETATM 71 LI LIG 1 2.867 0.943 -0.352 1.00 0.00 Li
HETATM 72 SE LIG 1 3.217 1.698 -0.479 1.00 0.00 Se
HETATM 73 BE LIG 1 3.420 3.640 -1.128 1.00 0.00 Be
HETATM 74 SI LIG 1 2.690 -3.917 -3.381 1.00 0.00 Si2-
HETATM 75 BE LIG 1 1.298 -4.933 -4.592 1.00 0.00 Be
HETATM 76 SI LIG 1 2.690 -1.467 -1.649 1.00 0.00 Si2-
HETATM 77 SE LIG 1 1.096 -4.425 -2.211 1.00 0.00 Se
HETATM 78 BE LIG 1 1.298 -2.484 -2.860 1.00 0.00 Be
HETATM 79 LI LIG 1 0.746 -2.731 -0.352 1.00 0.00 Li
HETATM 80 LI LIG 1 3.516 -3.786 -2.648 1.00 0.00 Li
HETATM 81 SE LIG 1 1.096 -1.976 -0.479 1.00 0.00 Se
HETATM 82 BE LIG 1 1.298 -0.034 -1.128 1.00 0.00 Be
HETATM 83 LI LIG 1 3.516 -1.336 -0.916 1.00 0.00 Li
HETATM 84 BE LIG 1 -0.823 -3.709 -1.128 1.00 0.00 Be
HETATM 85 LI LIG 1 4.989 -2.731 -0.352 1.00 0.00 Li
HETATM 86 BE LIG 1 3.420 -3.709 -1.128 1.00 0.00 Be
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CONECT 2 7 17 9 10
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CONECT 12 4 39 44 26
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EONCCT 16 4 5 8 44
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CONECT 36 18 51 53 54
CONECT 36 38 56
CONECT 37 12 28 39 43
CONECT 37 44 78 46 82
CONECT 37
CONECT 38 18 36 54 50
CONECT 38 56 39
CONECT 39 12 18 26 37
CONECT 39 38 43
CONECT 40 20 54 57 58
CONECT 40 56 84 43 59
CONECT 40
CONECT 41 26 75 78 63
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CONECT 42 16 32 44 47
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CONECT 43 20 26 37 39
CONECT 43 40 58 52 59
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CONECT 44 37 42 43 47
CONECT 44
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CONECT 45
CONECT 46 26 28 30 37
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CONECT 46 76 70
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CONECT 56 84 77 78
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CONECT 65 41 63 78 74
CONECT 65 80 66
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CONECT 66 65 69
CONECT 67 46 78 81 82
CONECT 67 80 86 69 83
CONECT 67
CONECT 68 35 70 72 73
CONECT 68
CONECT 69 46 60 64 66
CONECT 69 67 82 76 83
CONECT 69 70
CONECT 70 24 27 31 35
CONECT 70 46 60 61 64
CONECT 70 68 69 72
CONECT 71 49 82 83 72
CONECT 71
CONECT 72 49 61 68 70
9.3 .pdb file of Figures 6 and 7

Be$_{18}$HLi$_{36}$Se$_{28}$Si$_{15}$

HEADER CSD ENTRY Be$_{18}$HLi$_{36}$Se$_{28}$Si$_{15}$

AUTHOR GENERATED BY OPEN BABEL 2.3.2 [34] Be$_{18}$HLi$_{36}$Se$_{28}$Si$_{15}$

HETATM 1 SI LIG 1 2.150 0.026 -4.990 1.00 0.00 Si2-
HETATM 2 SE LIG 1 4.890 -1.881 -4.309 1.00 0.00 Se
HETATM 3 LI LIG 1 2.433 -2.383 -3.908 1.00 0.00 Li
HETATM 4 LI LIG 1 1.890 -1.881 -4.309 1.00 0.00 Li
HETATM 5 SI LIG 1 -0.850 0.026 -4.990 1.00 0.00 Si2-
HETATM 6 SE LIG 1 1.890 -1.881 -4.309 1.00 0.00 Se
HETATM 7 LI LIG 1 -0.567 -2.383 -3.908 1.00 0.00 Li
HETATM 8 LI LIG 1 1.620 0.645 -4.232 1.00 0.00 Li
| HETATM  | X       | Y       | Z       | Temp  | Occup  |
|---------|---------|---------|---------|-------|--------|
| 9       | -3.850  | 0.026   | -4.990  | 1.00  | 0.00   |
| 10      | -1.110  | -1.881  | -4.309  | 1.00  | 0.00   |
| 11      | -3.567  | -2.383  | -3.908  | 1.00  | 0.00   |
| 12      | -1.380  | 0.645   | -4.232  | 1.00  | 0.00   |
| 13      | -4.110  | -1.881  | -4.309  | 1.00  | 0.00   |
| 14      | -4.380  | 0.645   | -4.232  | 1.00  | 0.00   |
| 15      | 2.150   | -2.657  | -3.648  | 1.00  | 0.00   |
| 16      | 4.890   | -4.564  | -2.967  | 1.00  | 0.00   |
| 17      | 3.679   | -3.850  | -4.469  | 1.00  | 0.00   |
| 18      | 4.620   | -2.038  | -2.891  | 1.00  | 0.00   |
| 19      | -0.850  | -2.657  | -3.648  | 1.00  | 0.00   |
| 20      | 1.890   | -4.564  | -2.967  | 1.00  | 0.00   |
| 21      | 0.679   | -3.850  | -4.469  | 1.00  | 0.00   |
| 22      | 1.620   | -2.038  | -2.891  | 1.00  | 0.00   |
| 23      | -3.850  | -2.657  | -3.648  | 1.00  | 0.00   |
| 24      | -1.110  | -4.564  | -2.967  | 1.00  | 0.00   |
| 25      | 2.321   | -3.850  | -4.469  | 1.00  | 0.00   |
| 26      | 1.380   | -2.038  | -2.891  | 1.00  | 0.00   |
| 27      | -4.110  | -4.564  | -2.967  | 1.00  | 0.00   |
| 28      | -4.380  | -2.038  | -2.891  | 1.00  | 0.00   |
| 29      | 4.620   | -4.721  | -1.549  | 1.00  | 0.00   |
| 30      | 1.620   | -4.721  | -1.549  | 1.00  | 0.00   |
| 31      | -1.380  | -4.721  | -1.549  | 1.00  | 0.00   |
| 32      | -4.380  | -4.721  | -1.549  | 1.00  | 0.00   |
| 33      | 4.890   | 4.828   | -4.309  | 1.00  | 0.00   |
| 34      | 2.433   | 4.325   | -3.908  | 1.00  | 0.00   |
| 35      | 1.890   | 4.828   | -4.309  | 1.00  | 0.00   |
| 36      | -0.567  | 4.325   | -3.908  | 1.00  | 0.00   |
| 37      | 1.890   | 4.828   | -4.309  | 1.00  | 0.00   |
| 38      | -3.567  | 4.325   | -3.908  | 1.00  | 0.00   |
| 39      | -4.110  | 4.828   | -4.309  | 1.00  | 0.00   |
| 40      | 2.150   | 4.051   | -3.648  | 1.00  | 0.00   |
| 41      | 4.890   | 2.144   | -2.967  | 1.00  | 0.00   |
| 42      | 3.679   | 2.858   | -4.469  | 1.00  | 0.00   |
| 43      | 2.433   | 1.642   | -2.566  | 1.00  | 0.00   |
| 44      | 4.620   | 4.670   | -2.891  | 1.00  | 0.00   |
| 45      | -0.850  | 4.051   | -3.648  | 1.00  | 0.00   |
| 46      | 1.890   | 2.144   | -2.967  | 1.00  | 0.00   |
| 47      | 0.679   | 2.858   | -4.469  | 1.00  | 0.00   |
| 48      | -0.567  | 1.642   | -2.566  | 1.00  | 0.00   |
| 49      | 1.620   | 4.670   | -2.891  | 1.00  | 0.00   |
| 50      | 3.850   | 4.051   | -3.648  | 1.00  | 0.00   |
| 51      | -1.110  | 2.144   | -2.967  | 1.00  | 0.00   |
| 52      | 2.321   | 2.858   | -4.469  | 1.00  | 0.00   |
| 53      | -3.567  | 1.642   | -2.566  | 1.00  | 0.00   |
| 54      | 1.380   | 4.670   | -2.891  | 1.00  | 0.00   |
CONECT 26 78 80
CONECT 27 11 23 25 32
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CONECT 28 11 13 23 84
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