Int. j. adv. multidisc. res. stud. 2025; 5(1):409-416

Received: 02-12-2024
Accepted: 12-01-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

On the Interplanetary Cosmic-Space Temperature Fluctuations Application Possibility with Superconductors and Molecular Effect Modelling for Energy Optimization in Future Space Long-Voyages

[1] **Francisco Casesnoves**

[1] PhD Engineering, MSc Physics-Mathematics, Physician, Independent Research Scientist, International Association of Advance Materials (IAAM), Sweden

[1] PhD Engineering, MSc Physics-Mathematics, Physician, Independent Research Scientist, UniScience Global Scientific Member, Wyoming, USA

Corresponding Author: **Francisco Casesnoves [Email:** casesnoves.research.emailbox@gmail.com**]**

DOI: https://doi.org/10.62225/2583049X.2025.5.1.3667

Abstract

Superconductors Molecular Effect Model (MEM) was published in a series of contributions for High Temperature Superconductors (HTSC) Type I and II. A cautious pre-hypothesis is presented for future applications with these HTSC for optimizing the exploitation of cosmic space temperature fluctuations, not exclusively related to MEM. This pre-hypothesis project for possible upcoming missions applications, both in human-crew or robotic spacecrafts is explained and technically justified. Advantages and inconvenients are discussed. A review of 3D Interior and Graphical Optimization with HTSC MEM model, namely Hg-Cuprates, is included with main Critical Temperature numerical algorithms/formulas previously developed. This updated refinement for Hg-Cuprates MEM shows error in T_C prediction ≈ 4 K, and is the forward improvement whose errors have to be continued decreasing in next MEM development stages.

Keywords: Superconductors Molecular Effect Model (MEM), High Temperature Superconductors (HTSC), Spacecraft, Interplanetary Mission, Critical Temperature (T_C), Power Engineering, Interplanetary Spatial Voyages, Robotic Spacecrafts (RS)

1. Introduction and Objectives

Mathematical modelling of planetary stratospheric and outer space temperatures is diverse and extensive in contemporary aerospace research [62, 1-11]. As an introduction it is shown some examples of the simple equations, other models could be simple or more complicated [2-11]. Here it is shown some models as an illustrative initiation.

One model for the stratospheric temperature T_S at earth planet, based on the Stefan-Boltzmann law to find the temperature based on energy emitted and energy integrated by sun irradiance reads,

$$T_S \cong \frac{T_E}{2^{1/4}};$$

where,

T_S is the stratospheric temperature .
T_E the effective radiative temperature of the Earth . (1)

Other very simple model that shows the approximated average temperature at earth planet, [62], reads,

$$T \cong \frac{3612}{D};$$

where

T is temperature (Kelvin) .
D is distance from Sun (Million km) . (2)

Just to remark that these models are illustrative. More complicated models, taking account outer space temperature, are usually made for planetary atmospheres of solar system, not for outer interplanetary space within solar system. The distance from the sun and solar corona constitutes in general an important parameter in those models.

For example, from [63], the temperature of air within the spacecraft, calculated by a system of partial differential equations, based on layers of the spanecraft is,

$$T_i^4 \cong T_i^{K+1} \times \left[T_i^K\right]^3 ;$$

where,

T_i : Temperature of every layer (i) of spacecraft with multilayer structure of screen-vacuum thermal insulation under the influence of solar radiation [directly from 63] . That is the analytic solution of the system of partial differential equations .

K: Constant that depends of the number of layers. (3)

However, this approximation is very different mainly from orbital temperatures within Solar System and interplanetary ones.

The fluctuations in orbital space, approximately follows the constraint: Temperature [-200, +200] (Celsius) [2-11]. That is, the minimum approximates to 0 K degrees. T solar corona or surroundings, temperatures can reach trillions of degrees [2-11].

The most important difficulties for an interplanetary mission, briefed at Tables 1, are,

1. The long distances, that imply a high velocity close to light and is function of propulsion and energy. Recent calculations for a Mars mission is around 3 years. Its is considered too long time that could create many difficulties, Tables 1-2. Reduction to about 1 year may be necessary [1]. The approximate certain technology is capable of possibly reaching about 10% the light speed, [1-11].
2. The biomedical human constraints to endure during long journeys and arrive safely and healthy. Just the same reasons from Tables 1-2.

The interplanetary expeditions show a rather high number of technological constraints [2-6]. The most important, but not the less, are: The velocity that should be near to light speed, otherwise the distance cannot be covered in optimal time, and this velocity magnitude also could create biomedical problems for the human crew. The biomedical difficulties come from the usual special medicine pathology. That is, osteophorosis, neurological disorders, muskuloeskeletal diseases, and others Tables 1. The speed is function of the engines, the energy sources and technology (that is the article focus for SC and HTSC applications), and the biomedical difficulties for the human crew, provided the spacecraft is tripulated, not robotics. These unavoidable difficulties to be resolved with success possibilities for the spacecraft trip and future transport spacecrafts constitute a great challenge in the future aerospatial investigation.

The essential starting points, [1-11, 62] are as follows,

1. It is an objective fact that there are significant temperature fluctuations at interplanetary outer space.
2. Therefore, this fact implies that there is an energy fluctuation free.
3. Physics, engineering, and other science branches could get methods to approach this energy.
4. This is an open research field for multiple usages. The energy might not become cover total demand, but a maybe a high portion.

Table 1.1: Part I. Some difficulties and challenges for interplanetary voyages/transport [2-6]. Some of them are not applied for robotic expeditions

PART I: BRIEF OF INTERPLANETARY VOYAGES SCIENTIFIC COMPLEXITIES [2-6]					
DIFFICULTIES			COMPULSORY REQUIREMENTS		
Difficulty	**Task**	**Supplementary**	**Requirement**	**Task**	**Supplementary**
Propulsion	Huge Improvement necessary and at present lack of systems to reach sufficient high speed and energy for long voyages	Research task compulsory	Velocity Close to light, or at least about 50% (currently maximum hypothesis reacheable is 10%.	New Propulsion, this is a very important part. Huge research for propulsion system is mandatory	Biomedical problem for relativistic speed. Polemic: the higher speed, the shorter voyage time, and the higher speed the more possible biomedical problems.
Spacecraft manufacturing and design. Communications with base. Material degradation for radiation.	Very important, as trip is long, SUPERCONDUCTORS APPLICATIONS	SUPERCONDUCTORS APPLICATIONS. Electronics, Energy, Biomedical, Shielding, minimum required comfort. Long distances imply significant communication delays.	Physical crew conditions	Training. Exercise apparatus at spacecraft	Training is for crew and for any eventual travelers/passengers, not necessary in robotic spacecrafts (RS)
Unpredictable propulsion problems or accidents	Prediction work for propulsion and spacecraft mechanics	This could occur as it happened in space exploration history. Meteorites, micro-meteoroids, debris, space objects.	Mental crew conditions	Training and at least one staff with psychology /psychiatry preparation	Training is for crew and for any eventual passengers . Amusing activities preparation. Not necessary in robotic spacecrafts (RS)
Electromagnetic storms, magnetic storms	Geomagnetic storms are global disruptions of the planets magnetic Field.	They can damage spacecrafts, humans, spacecraft grids, and materias, among others	Diet	Vital and optimal for survival	Essential optimal and previously studied. Reserves of food for emergencies or lost or damage/contamination of food
Solar storms, solar flares	From [6]: 'Space storms produce the most penetrating radiation, which can disrupt communications and cause power line transmission failures"	Outer space storms could be mostly solar or non-solar [6]	Magnetic protection	Protection in spacecraft materials, shielding,and travelers and crew uniforms or clothes, magnetic storms	Magnetic storm can damage electronics and power engineering at spacecraft also. Solar storms also.

Table 1.2: Part II. Some difficulties and challenges for interplanetary voyages/transport [2-6]. Some of them are not applied for robotic expeditions

PART II: BRIEF OF INTERPLANETARY VOYAGES SCIENTIFIC COMPLEXITIES [2-6]					
DIFFICULTIES			COMPULSORY REQUIREMENTS		
Difficulty	**Task**	**Supplementary**	**Requirement**	**Task**	**Supplementary**
Medical: radiation [all medical complications from 6 mainly, some are at short time probability, others may come at long time] radiation	Radiation protection: radiation (cosmic mainly) could become source for other medical complications	Research in space radioprotection	Radiation protection	Protection in spacecraft materials, shielding,and travelers and crew uniforms or clothes	Cosmic radiation rays can damage structures and energy devices at spacecraft. The radiation absorbed dose in long voyages can easily overpass the ICRP, and ICRU standards dose levels recommended
Medical: osteophorosis	Diet plus supplements	Physical exercise	Physical exercise + supplements	Physics exercise facilities at spacecraft	This seems not be important but is essential for physical and mental health conservation
Medical: Brain and Neurology and Sleep disfunctions	Biomedical prediction, and this is very important	Medication if necessary	Training, medication for eventual diseases and basic surgery facilities	Pharmacy set-up storage and at least one member in staff for emergency surgery, accidents etc	Not necessary in robotic spacecrafts (RS)
Medical: Space Adaptation Syndrome and Space Sickness	Usual medical treatment	Training before voyage	Training, emergencies	Automatic and fast response for eventual emergencies	Periodic exercises for crew and travelers
Medical: Vision Problem, catharatas	Prevention during mission	Research for prevention and prediction	Training, social	Prevent any social problem among travelers	Not necessary in robotic spacecrafts (RS)
Medical Others: Cardiovascular, Mental Health, Digestive, Inmuno System, Cancer (long term), Musculoeskeletal	Control by medical staff during mission, medical periodic checks from earth base	Research for prevention and prediction	Training, priorities	Setting clearly importance of priorities at every amount of tasks	To save and optimize time and effort, human energy available during voyage
Unpredictable biomedical problems	Prediction study	These complications could occur	Bacteria or virus infections	Prevention and prediction	Research for prevention and prediction

Actually, aerospace research is focused on next engines generations that could reach both optimal speeds and energy resources. All of those are extremely difficult. Superconductors low resistivity may offer a technical solution to save energy and also might provide with almost unexpensive energy resources during the voyage.
This study deals with the presentation of an energy-source variant that might be useful for interplanetary voyages in solar system. Given the wide range of temperature fluctuations, that apparent difficulty could be approached for optimizing those energy system depending on superconductors technology.
The first part of the article deals with geophysical and electrophysics arguments that could justify the advantage of using superconductors to optimize both energy consumption and savings during interplanetary trip. The second one shows a computational example of improved software in 3D Graphical Optimization, in this study with GNU Octave, related to Molecular Effect Model for Hg-Cuprates (superconductor Type II).
A number of pre-hypothesis applications are described in the article, derived from the recent literature, [1-11]. These ones are diverse, however at present the fast development of SC and HTSC research, are not limited, Tables 1-3.
Grosso modo, the study presents a pre-hypothesis about SC and HTSC technology possible applications for interplanetary voyages. A computational algorithmic and 3D Imaging–Processing example for Hg-Cuprates is also shown.

2. Pre-hypothesis Justifications

Table 2 shows the rationale to support the SC and HTSC for spacecrafts missions. The main point is to approach the temperatures fluctuations at outer space, and avoid risk in energy [1-11].

Table 2: Rationale of some possible SC and HTSC applications for interplanetary missions [1-11]

PRE-HYPOTHESIS RATIONALE	
BASIS [9,10]	**POSSIBLE APPLICATION [9,10]**
Cables required for fast charge/discharge	High power energy savings during time of optimal T_C
Superconducting magnets	Specific power (volume, mass)/discharge time duration,
Superconducting wires	For those alternative wires that work at optimal T_C
Cryostat energy savings	The materials of SC and HTSC would not need cooling energy
Supercomputers	Supercomputers for a mission of years or long time, that demand high electrical energy
Superconducting magnetic energy storage (SMES)	Investment and running costs (per kWh, per kW)
Propulsion (important)	High power energy savings during time of optimal T_C

3. Project Highlights

The main objectives for SC and HTSC applications on power engineering resources during interplanetary voyages would be its use taking advantage of temperature fluctuations. Outer space temperatures could approximate the 0 K degrees as minimum and of around 400 C degrees [2-6, 9-10]. The solar cells power energy influx can be used in advantage-conditions by using SC or HTSC through these possible ways,

1. Propulsion engines, parts of propulsion engines, transmission lines, or other parts
2. Spacecraft electrical power demands and savings
3. All types of batteries charging process.
4. Communication devices that require high-voltage and electrical intensity, and fast discharge/charge.
5. High-demanding energy computational systems that require elevated electrical power.
6. Given the constant random magnetic fields, cosmic radiation, and similar factors that cause strains in spacecraft systems, the faster the electrical power is transmitted, the less probability these random outer space difficulties could occur.

Relatively recent investigation line for SC and HTSC are briefed on Table 2 from [11, 60]. These new lines could get improvements for applications on interplanetary missions also.

Table 3: From [11, Table at that article extracted from 60 highlights], Some future strategic research lines according [60, Sarrao, J; Nault, R. (2006). Basic research needs for superconductivity] criteria. Note: That is an overview and brief resume with data of a prestigious institution among others. Applications for interplanetary voyages emerge from these planned advances

SUPERCONDUCTORS POWER-ENGINEERING AND ELECTRONICS SOME FUTURE STRATEGIC RESEARCH LINES [From 49, Sarrao, J ; Nault, R. (2006). Basic research needs for superconductivity.]	
PRIORITY [Directly From 49, Sarrao, J ; Nault, R. (2006)]	**REASONS AND OBJECTIVES**
Identifying simplified criteria for screening materials and implementing them into Computational Algorithms	Elaboration of screens for new-potential superconductors will enable this search, because it will allow identification of the most likely materials with faster/slower conductivity. Then, substitution of classical SC with more reliable and operational ones.
Integrating Synthesis and Surface-Sensitive Characterization Techniques	There are new laboratory techniques to be used for these objectives, such as molecular beam epitaxy (MBE), applicable for films of various complex oxides.
Computational Libraries of Potential Superconductors	Efficacious and efficient techniques/methods for creating materials libraries that which could be used for new properties.
Developing Reliable and Fast Methods to Determine the Surface Structure	This is an important point as it saves laboratory time for characterization of potential new superconductors, and therefore increases probabilities of advances.
Enabling materials for superconductor utilization	Materials apparently unable to show superconducting properties could get that characteristics by using modifications.
Low-temperature Insulators	Insulators are essential to reach optimal critical temperatures. That involves both mechanical improvements and thermal properties research.
Magnets and Dielectrics	More efficacious and efficient transformers for more optimal magnetic fields and capacitors.
Control Systems	For example, MOSFETs, capacitors, inductors with better cryogenic properties given by new materials.
Maximize Refrigeration Efficiency	That is a field of convergence for several branches, namely, Chemistry, Mechanics, Thermodynamics and Thermo-Physics.

4. Hg-Cuprates MEM Advances and Results, GNU Octave Example

This section show a recent stage for mathematical modelling of MEM with GNU Octave to obtain approximated critical temperature, T_C. The optimized equations are shown, and the 3D imaging processing also, Fig 1. Error increases after 120 K.
The MEM model was developed in publications series, [3, 11, 59, 61], and at present the errors and intervals applicability is getting better, but not matching the model requirements completely. Here the recent equation is shown, with new 3D imaging processing variant in GNU Octave. The imaging GNU Octave results describes the Hg-Cuprates MEM model with acceptable vision, Fig 1. The present-stage equation, after Algorithm Chebyshev Optimization for Hg-Cuprates MEM model, [11], reads,

$$T_C = (-478.778138031430e\text{-}009 \bullet P^3 + 1.25347541665985e\text{-}003 \bullet P^2 + \ldots$$
$$\ldots -976.861475440786e\text{-}003 \bullet P + 326.607398423101e{+}000 - \ldots \ldots$$
$$[292.980091430742]^{0.46}) ;$$

[Casesnoves Bioengineering Laboratory, Algorithm 211a]

were,

T_C : Critical temperature (K);

P : Molecular Mass for every Hg-Cuprates compound. (4)

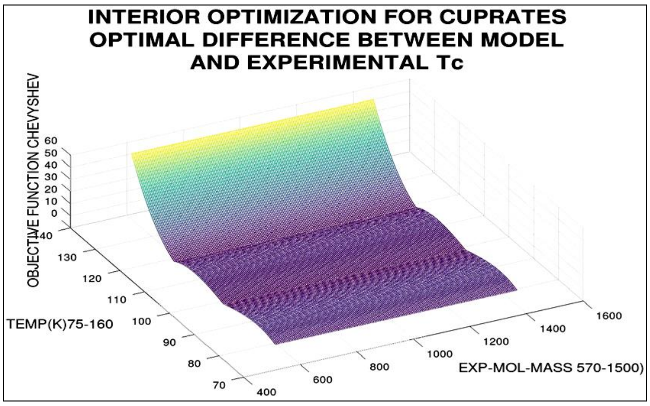

Fig 1: [Casesnoves Bioengineering Laboratory, Algorithm-Graph 211a]. Present MEM model 3D imaging-processing for Hg-Cuprates HTCS. It is observed that Matlab has more 3D Imaging Processing varied tools, although the primary imaging quality is almost equal

5. Future Interplanetary Voyage Applications

From previous sections can be guessed the importance of aerospace research for interplanetary missions, given the constant degradation of earth planet. Therefore, Tables 1-3 conditions are applicable to develop capabilities for future in terms of survival prediction/prevention.

Table 4: From [9, 10], brief of pre-hypothesis applications

PRE-HYPOTHESIS APPLICATIONS	
BASIS [9,10]	**POSSIBLE APPLICATION [9,10]**
Interplanetary voyages	High power energy savings during time of optimal mission
Superconducting computers processors materials	New generation of microprocessors
Superconducting grids and wires	For those alternative grids/wires that work at optimal T_C
Cryostat energy savings	The materials of SC and HTSC would not need cooling energy
Rotating machine generators motors	During optimal temperatures for superconductors
Superconducting magnetic energy storage	System extracts information from the grid system and controls the superconducting magnet output power in function of to the spacecraft demands of the grid system.
Propulsion	High power energy savings, when the outer space temperature is applicable, during time of optimal T_C

6. Discussion and Conclusions

Primarily, according to scientific ethics standards, it is obliged to remark that this study constitutes a pre-hypothesis, based on series of SC and HTSC modelling publications for MEM. This is the first article-stage part in the field. Given this specification, the objectives of the research are a number of forthcoming concepts/ideas.
Therefore, the number of objectives of the study were diverse, divided in Part I and Part II. For Part I, firstly to explain and show the pre-hypothesis, based on literature review and previous Author's publications. Secondly to justify the rationale of the ideas and the practical engineering applications for interplanetary future voyages. Complementary, a series of applications for power engineering were presented.
Par II constitutes a Hg-Cuprates MEM model group of refinements, both in optimized numerical and 3D imaging-processing graphs. The T_C equation after refinements is presented.
The pre-hypothesis was justified according to actual hurdles for interplanetary missions, mainly for human voyagers and also robotics expeditions. It is a pre-informative presentations of future-possible ideas based on literature and Authors' SC and HTCH MEM model. Therefore, from this point of view, the study constitutes a rationalized introduction.

In summary, a cautious pre-hypothesis for future interplanetary missions was shown with further developments and example of Hg-Cuprates MEM model with 3D Optimization Imaging Processing.

7. Scientific Ethics Standards

Important remarks: (1) IMPORTANT: SOFTWARE, TEXT, IMAGES, WHOLE ARTICLE IS MADE BY AUTHOR, AND NO AI PROGRAMS, SYSTEMS, OR SOFTWARE FOR MAKING THE PAPER WAS USED, ACCORDING TO STANDARD EUROPEAN UNION AND SCIENTIFIC COMMUNITY ETHICS. IF AI IS USED AT ANY OF THE PUBLICATIONS, IT IS PRECISELY SAID WHAT WAS USED, HOW AND THE ARTICLE PLARTS. (2) Images and table-data reminders from previous contributions are intended for explicit improved understanding. Author's references from previous publications are set for readers getting all complementary information. This study contains improved programming, [Casesnoves, May 7th, 2024], and engineered software that was developed for numerical Hg-Cuprates imaging-processing database, Second Part. Formulas applied/included are from previous publications. Graphical Optimization Methods were created by Dr Francisco Casesnoves in 3rd November 2016, and Interior Optimization Methods in 2019. This article has previous papers information, whose inclusion is essential to make the contribution understandable. This study was carried out, and their contents are done according to the International Scientific Community and European Union Technology and Science Ethics. References: 'European Textbook on Ethics in Research'. European Commission, Directorate-General for Research. Unit L3. Governance and Ethics. European Research Area. Science and Society. EUR 24452 EN. And based on 'The European Code of Conduct for Research Integrity'. Revised Edition. ALLEA. 2017, and [58]. This research was completely done by the author, the computational-software, calculations, images, mathematical propositions and statements, reference citations, and text is original for the author. When a mathematical statement, algorithm, proposition or theorem is presented, demonstration is always included. When a formula is presented, all parameters are detailed or referred. If any results inconsistency is found after publication, it is clarified in subsequent contributions. When a citation such as [Casesnoves, 'year'] is set, it is exclusively to clarify intellectual property at current times, without intention to brag. The article is exclusively scientific, without any commercial, institutional, academic, any religious, religious-similar, non-scientific theories, personal opinions, political ideas, or economical influences. When anything is taken from a source, it is adequately recognized, or put anu mber in a remark. Ideas and some text expressions/sentences from previous publications were emphasized due to a clarification aim. Number of references is large to provide literature in open access for public health care institutions.

8. References

1. Moldwin B. An Introduction to Space Weather. De Gruyter, 2018.
2. Bothmer V, Daglis I. Space Weather Physics and Effects. Springer, 2007.
3. Casesnoves F. Interior Optimization Methods with electronics Applications Examples. Eliva Press, 2023.
4. Milone E, Wilson W. Solar System Astrophysics. Springer, 2014.
5. McFadden L, Weissman P, Johnson T. Encyclopedia of the Solar System. Elsevier, 2007.
6. Gibson D. Terrestrial and Extraterrestrial Space Dangers: Outer Space Perils, Rocket Risks and the Health Consequences of the Space Environment. Bentham Science Publishers Ltd, 2015.
7. Hanslmeier A. The sun and space weather. Springer, 2007.
8. Coster A, Erickson P, Lanzerotti L. Space Weather Effects and Applications. Wiley, 2021.
9. Yinshun W. Fundamental elements of applied superconductivity in electrical engineering. Wiley, 2013.
10. Melhem Z. High temperature superconductors (HTSC) for energy applications. Woodhead Publishing, 2012.
11. Casesnoves F. Superconductors Molecular Effect Model Fundamentals and Review of Isotope Effect with 3D Graphical-Mathematical Interior Optimization. Journal of Engineering and Applied Sciences Technology. SRC/JEAST-384, 2024. Doi: doi.org/10.47363/JEAST/2024(6)270.
12. Vora AM. Modified Transition Temperature Equation for Superconductors. Chin. Phys. Lett. 2008; 25:2162. [CrossRef].
13. Casesnoves F. Interior Optimization Methods with Electronics Applications. Int. J. Sci. Res. Sci. Eng. Technol. 2020; 7:428-436. [CrossRef]
14. Casesnoves F. Advanced Interior Optimization Methods with Electronics Applications. Int. J. Sci. Res. Sci. Eng. Technol. 2020; 7:97-110. [CrossRef]
15. Casesnoves F. Multiobjective Interior Optimization Computational Methods for Electronics BCS Superconductivity. Int. J. Sci. Res. Comput. Sci. Eng. Inf. Technol. 2020; 6:280-293. [CrossRef]
16. Plakida N. High-Temperature Cuprate Superconductors Experiment, Theory, and Applications. In Springer Series in Sol-id-State Sciences; Springer: Berlin/Heidelberg, Germany, 2010. ISSN 01711873.
17. Alexandrev AS. Theory of Superconductivity, from Weak to Strong Coupling. Series in Condensed Matter Physics; Institute of Physics Publishing: Philadelphia, PA, USA, 2003.
18. Khare N. Handbook of High-Temperature Superconductor; Marcel Dekker: New York, NY, USA, 2003. ISBN 0824708237.
19. Buschow K. Magnetic & Superconducting Materials, 2nd ed.; Elsevier: Amsterdam, The Netherlands, 2003.
20. Seidel P. Applied Superconductivity;Wiley-VCH: Hoboken, NJ, USA, 2015; 1,2.
21. Drechsler S, Mishonov T. High-T C Superconductors and Related Materials Material Science, Fundamental Properties, and Some Future Electronic Applications; Springer Science Media: Berlin/Heidenberg, Germany, 1998.
22. Kazufumi I, Bangti J. Inverse Problems, Tikhonov Theory and Algorithms; Series on Applied Mathematics; World Scientific: Singapore. 2015; 22.
23. Casesnoves F. Mathematical Models and Optimization of Erosion and Corrosion. Ph.D. Thesis, Taltech University, Tallinn, Estonia, 14 December, 2018. ISSN 25856898.

24. Casesnoves F. Die Numerische Reuleaux-Methode Rechnerische und Dynamische Grundlagen mit Anwendungen (Erster Teil); Sciencia Scripts: Chisinau, Moldova, 2019. ISBN 139786200895608/106200895600.
25. Casesnoves F. Primary Modelling for Electromagnetic Waves Transmission in Extreme Weather Conditions. Int. J. Innov. Res. Sci. Eng. Technol. 2018; 7:10294-10300. [CrossRef]
26. Casesnoves F. The Numerical Reuleaux Method, a Computational and Dynamical Base with Applications. First Part; Lambert Academic Publishing: Saarland, Germany, 2019. ISBN 103659917478.
27. Darwin C. The Origin of Species; Barnes & Noble Classics: New York, NY, USA, 2004.
28. Haupt R, Haupt S. Practical Genetic Algorithms, 2nd ed.;Wiley: New York, NY, USA, 2004.
29. Abramowitz M, Stegun IA. Handbook of Mathematical Functions; U.S. Government Printing Office: Champaign, IL, USA. 1964; 55.
30. Casesnoves F, Suzenkov A. Mathematical Models in Biotribology with 2D-3D Erosion Integral-Differential Model and Computational-Optimization/Simulation Programming. Int. J. Sci. Res. Comput. Sci. Eng. Inf. Technol. 2017; 2:329-356. ISSN 24563307.
31. Casesnoves F, Antonov M, Kulou Piss. Mathematical models for erosion and corrosion in power plants. A review of applicable modelling optimization techniques. IEEE Xplore database and will be cross referred in SCOPUS. In Proceedings of the RUTCON2016 Power Engineering Conference, Riga, Latvia, 13 October, 2016.
32. Casesnoves F. 2D computational-numerical hardness comparison between Fe-based hardfaces with WC-Co reinforcements for Integral-Differential modelling. Key Eng. Mater. J. 2018; 762:330-338. ISSN 16629795. [CrossRef].
33. Casesnoves F, Surzhenkov A. Inverse methods for computational simulations and optimization of erosion models in power plants. In Proceedings of the RUTCON2017 Power Engineering Conference, Riga, Latvia, 5 December, 2017. [CrossRef]
34. Casesnoves F. Computational Simulations of Vertebral Body for Optimal Instrumentation Design. J. Med. Devices. 2012; 6:021014. [CrossRef]
35. Casesnoves F. Large-Scale Matlab Optimization Toolbox (MOT) Computing Methods in Radiotherapy Inverse Treatment Planning. In High Performance Computing Meeting; Nottingham University: Nottingham, UK, 2007.
36. Casesnoves F. A Monte-Carlo Optimization method for the movement analysis of pseudo-rigid bodies. In Proceedings of the 10th SIAM Conference in Geometric Design and Computing, San Antonio, TX, USA, 4–8 November 2007. Contributed Talk, 2007.
37. Casesnoves F. Applied Inverse Methods for Deformable Solid Dynamics/Kinematics in Numerical Reuleaux Method (NRM). Int. J. Numer. Methods Appl. 2013; 9:109-131.
38. Casesnoves F. Nonlinear comparative optimization for biomaterials wear in artificial implants technology. In Proceedings of the Applied Chemistry and Materials Science RTU2018 Conference Proceedings, Rajasthan Technical University, Kota, India, 17-18 March, 2018.
39. Allison J, Amako K, Apotolakis J, Araujo H, Dubois PA, Asai M, *et al*. Geant4 Developments and Applications. IEEE Trans. Nucl. Sci. 2006; 53:270-278. [CrossRef]
40. Batic M, Hoff G, Pia MG, Saracco P, Weidenspointner G. The Geant4 Simulation Toolkit. IEEE Nucl. Sci. Symp. Med. Imaging Conf. Seoul. 2013; 60:2934-2957.
41. Luenberger GD. Linear and Nonlinear Programming, 4th ed.; Springer: Berlin/Heidelberg, Germany, 2008.
42. Huang X. Does the isotope effect of mercury support the BCS theory? arXiv 2011, arXiv:1102.1467, 2011.
43. Hummel RE. Electronic Properties of Materials; Springer: New York, NY, USA, 2011.
44. Kasap F, Capper P. (Eds.) Springer Handbook of Electronic and Photonic Materials, 4th ed.; Springer: Berlin/Heidelberg, Germany, 2000. [CrossRef]
45. Kessel W. On a General Formula for the Transition Temperature of Superconductors. Naturforschung. 1974; 29a:445-451. [CrossRef]
46. Kulo P, Casesnoves F, Simson T, Tarbe R. Prediction of abrasive impact wear of composite hardfacings. Solid State Phenomena. In Proceedings of 26th International Baltic Conference on Materials Engineering; Trans Tech Publications: Bäch, Switzerland. 2017; 267:201-206. [CrossRef]
47. Luiz A. Superconductivity—Theory and Applications; InTechOpen: London, UK, 2010. ISBN 9789533071510.
48. Reynolds CA, Serin B, Nesbitt LB. The Isotope Effect in Superconductivity. I. Mercury. Phys. Rev. 1951; 84:691. [CrossRef]
49. Seri B, Reynolds CA, Nesbitt LB. Mass Dependence of the Superconducting Transition Temperature of Mercury. Letters to Editor. Phys. Rev. 1950; 80:761. [CrossRef]
50. Todinov M. Reliability and Risk Models; Wiley: New York, NY, USA, 2005.
51. Vidyasagar M. Nonlinear Systems Analysis, 2nd ed.; Prentice Hall: Hoboken, NJ, USA, 1993.
52. Wesche R. Chapter 50. High-Temperature Superconductors. In Springer Handbook of Electronic and Photonic Materials; Springer: Berlin/Heidelberg, Germany, 2017.
53. Parinov I. Microstructure and Properties of High-Temperature Superconductors, 2nd ed.; Springer: Berlin/Heidelberg, Germany, 2017.
54. Fossheim K, Sudbø A. Superconductivity Physics and Applications; Wiley: New York, NY, USA, 2004.
55. Wang Y. Fundamental Elements of Applied Superconductivity in Electrical Engineering; Wiley: New York, NY, USA, 2013.
56. European Textbook on Ethics in Research. European Commission, Directorate-General for Research. Unit L3. Governance and Ethics. European Research Area. Science and Society. EUR 24452 EN, 2021. Available online:

https://op.europa.eu/en/publicationdetail/-/publication/12567a07-6beb-4998-95cd-8bca103fcf43 (accessed on 28 June 2021).
57. ALLEA. The European Code of Conduct for Research Integrity, Revised ed.; ALLEA: Bern, Switzerland, 2017.
58. Swedish Research Council. Good Research Practice; Swedish Research Council: Stockholm, Sweden, 2017. ISBN 978-91-7307-354-7.
59. Casesnoves F. Superconducting materials critical temperature models designed with 3D interior Optimization methods. Scientific talk and Proceedings Conference. Invited Talk at 3rd Global Summit on Graphene and 2D Materials (2DMAT2023) held Virtually on August 24-25, 2023.
60. Sarrao J, Nault R. Basic research needs for superconductivity. Report on the Basic Energy Sciences Workshop on Superconductivity, 2006.
61. Casesnoves F. Genetic Algorithms for Interior Comparative Optimization of Standard BCS Parameters in Selected Superconductors and High-Temperature Superconductors. Standards. 2022; 2:430-448. Doi: https://doi.org/10.3390/standards2030029.
62. NASA; Divulgative, 2012. http://spacemath.gsfc.nasa.gov. SpaceMath@NASA.
63. Kyaw Y, Colls. Mathematical modelling of the effect of heat fluxes from external sources on the surface of spacecraft. Journal of Applied Engineering Science. Paper number: 18(2020)4. 2020; 753:732-736.