BERC Programme
2018-2021

Severo Ochoa Excellence
Accreditation 2018-2022
"If people do not believe that mathematics is simple, it is only because they do not realize how complicated life is"

von Neumann, 1947
**Objective:** To develop new mathematical methods, robust numerical schemes and software to solve complex and large-scale challenging real-life problems on massively parallel computers.

**Description:** We analyse modern numerical methods such as advanced Finite Element (AFE) and Finite Volume (FV) techniques applied to stationary and time-dependent problems. In addition, we develop new meshless multiscale methods such as Smoothed Particle Hydrodynamics (SPH) or Dissipative Particle Dynamics (DPD) applied to complex fluids and mesoscopic flow problems.

**Applications:** Characterisation of the Earth’s subsurface composition for CO2-sequestration and oil or gas extraction; dynamics of complex particulate fluids, microfluidics, rheology; CFD applied to complex flows that rise in a number of engineering sectors including environmental, chemical/manufacturing, polymer/food processing and biomedicine.
Objective: Development of novel theoretical and computational tools for efficient and detailed simulation of multi-scale complex systems describing real life problems in biology, medicine, public health and society.

Description: Improved algorithms, efficient sampling techniques, advanced models combined with observational data ensure a full exploitation of the capabilities of modern HPC in tackling the mathematical challenge of strong coupling across scales, adaptive and emergent dynamics. Pushing the boundaries of mathematics and interdisciplinary knowledge helps to reveal hidden structures of the complex systems.

Applications: Patient-specific simulation (cardiovascular, brain, cancer), neurodegenerative diseases, drug design, self-assembly in bio-chemical processes, energy materials modeling and uncertainty quantification. Targeted at biologists, clinicians and industries.
Objective: At the interface between Mathematics and Physics is the so-called Mathematical Physics that at BCAM is represented by the research lines in Quantum Mechanics, Statistical Physics and Singularity Theory & Algebraic Geometry.

Description: We study several questions of classical physics that although long known, are still not understood from the mathematical perspective, microscopic origin of macroscopic laws (like in electricity) and natural phenomena of front motion embedded into random environments. More theoretically, we study the geometry of Singularities appearing in Algebraic Geometry.

Applications: Our methods could apply to, future applications of quantum technologies or forecast of wildland fire propagation to preserve natural heritage, criptography and string theory.
**Objective:** We explore and exploit the deep connections between Partial Differential Equations, Harmonic Analysis, and Applied Mathematics so as to describe the most diverse phenomena.

**Description:** The attempt to efficiently describe real-life phenomena leads to mathematical models, often expressed in terms of PDEs, capturing the essential features of the phenomena. Solving these equations implies the use and development of sophisticated techniques of analysis together with the realisation of numerical simulations to eventually determine the validity of the models.

**Applications:** The understanding of the fundamental principles that control relevant phenomena in physics and biology could eventually become of use for scientists working on those fields. We also expect to apply the efficient algorithms developed by our numerical simulations in real life problems.
Objective: To develop new statistical, machine learning and optimisation methods that can extract knowledge from the large amount of data generated nowadays.

Description: In the applied statistics field, the main topics of our research are semi-parametric regression, multidimensional smoothing, (Bayesian) hierarchical models, computational statistics... Regarding Machine learning, we work on supervised and unsupervised classification of massive data, probabilistic graphical models, time series, Bayesian optimization, etc. In optimization we pursue the developments of efficient metaheuristics methods.

Applications: Massive data and optimization problems from financial to social media, marketing, medical domains (diagnosis and prognosis), genetics, environmental modelling, demography and biostatistics, logistics, scheduling and planning.
People

- 1 Scientific Director
- 23 Research Line leader and BCAM Researchers
- 39 Postdoctoral Fellows
- 26 PhD Students
- 1 IT Technician
- 10 KTU Research Technicians
- 8 Administration Staff Members
- 22 External Scientific Members

Total: 108
Scientific Output

191 publications indexed

83,2 % articles in Q1

41,9 % articles in D1

BCAM h-index 33

Source: Scopus
# 1st Decile Journals

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<td>Computer Methods in Applied Mechanics and Engineering</td>
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<td>Transactions of the American Mathematical Society</td>
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<td>Transportation Research Part C: Emerging Technologies</td>
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Master & PhD Thesis

- **27 ongoing PhD students in 2019**
- **13 Thesis defended in 2019**
- **5 Master thesis defended in 2019**
- **11 new PhD students in 2019**
Participants in our Programmes

26 Interns

174 Visitors

19 Visiting Fellows
2019 Industrial Collaborators

- Obra Social 'la Caixa'
- IBERDROLA
- Fundación BBVA
- AVÍA
- Etxe-tar group
- Baltogar
- Texas
- SeniorGrowth
- Lagun ARO
- MedLumics
- [math-in]
- IPF
- B/S/H/
- Repsol
- ITP Aero
- lantek
- Innobasque
- Athletic Club
Signed agreements in 2019

2019 New International Agreements

Isaac Newton Institute for Mathematical Sciences

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Tsinghua University
2019 Dissemination Activities

General Dissemination

The promotion of scientific promotion: Aupa!uz, Talentia, Lego League Euskadi, etc.
Public Dissemination: Bidebarrieta, Art District, Matemozioa, Pint of Science, etc.
The press and other media (TV, radio, etc.)
Social networks launching

Scientific & Transfer activities

39 Seminars
9 Workshops
17 Courses
2 Other activities
Public and Private Funding

[EUSKO JAURLARITZA GOBIERNO VASCO]
[ikerbasque Basque Foundation for Science]
[Agencia Estatal de Investigación]
[Gobierno de España Ministerio de Ciencia, Innovación y Universidades]
[Excelencia Severo Ochoa]
[Europe]
[Interreg Europe]
[Obra Social "la Caixa"]
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