Geometric Science of Information
SEE/SMF GSI’17 Conference
Mines ParisTech

GSI’17 General Chairmen: Frédéric BARBARESCO*, Frank NIELSEN**
& Silvère BONNABEL***

(*) President of SEE ISIC Club (Ingénierie des Systèmes d’Information de Communications)
(**) LIX Department, Ecole Polytechnique, (*** CAOR Lab, Mines ParisTech,
Michel Marie Deza died on 23 November 2016 in an accidental fire in his apartment in Paris. He was a Soviet and French mathematician, specializing in combinatorics, discrete geometry and graph theory. He was director of research at the French National Centre for Scientific Research (CNRS), the vice president of the European Academy of Sciences, a research professor at the Japan Advanced Institute of Science and Technology, and one of the three founding editors-in-chief of the European Journal of Combinatorics.

https://en.wikipedia.org/wiki/Michel_Deza

2012 video of Michel Marie Deza at IRCAM for Brillouin Seminar on « Geometric Science of Information »
http://archiprod-externe.ircam.fr/video/VI02027700-282.mp4


Marcel Berger greatly contributed to mathematics, through his own publications, for example on holonomy groups, symmetric spaces, curvature pinching and the sphere theorem, spectral geometry or systolic geometry. His influence goes far beyond his research papers. His books and surveys have inspired not only his students, but a much broader audience. Important features of Marcel Berger’s mathematical heritage are also his seminar and his influence on the round tables organized by his friend Arthur L. Besse. Marcel Berger’s Riemannian geometry seminar held at the Universite Paris VII in the nineteen-seventies and eighties, hosted lectures by both reputable mathematicians and young researchers. For the participants, it was a unique place for lively and informal mathematical discussions and exchanges, as well as inspiration.

SEE at a glance

- Meeting place for science, industry and society
- An officially recognised non-profit organisation
- About 2000 members and 5000 individuals involved
- Large participation from industry (~50%)
- 19 «Clubs techniques» and 12 «Groupes régionaux»
- Organizes conferences and seminars
- Initiates/attracts International Conferences in France
- Institutional French member of IFAC and IFIP
- Awards (Glavieux/Brillouin Prize, Général Ferrié Prize, Néel Prize, Jerphagnon Prize, Blanc-Lapierre Prize, Thévenin Prize), grades and medals (Blondel, Ampère)
- Publishes 3 periodical publications (REE, …) & 3 monographs each year
- Web: [http://www.see.asso.fr](http://www.see.asso.fr) and LinkedIn SEE group
- SEE Presidents: Louis de Broglie, Paul Langevin, …

1883-2017: From SIE & SFE to SEE: 134 years of Sciences

Société de l'électricité, de l'électronique et des technologies de l'information et de la communication

1881: Exposition Internationale d'Electricité
1883: SIE Société Internationale des Electriciens
1886: SFE Société Française des Electriciens
2013: SEE 17 rue de l’Amiral Hamelin 75783 Paris Cedex 16
Mines ParisTech
Graduate School
234 years of History
He left England toward the end of the 11th century for Tours in France.

Adelard taught for a time at Laon, leaving Laon for travel no later than 1109.

After Laon, he travelled to Southern Italy and Sicily no later than 1116.

Adelard also travelled extensively throughout the "lands of the Crusades": Greece, West Asia, Sicily, Spain, and potentially Palestine.

Adelard of Bath was the first to translate Euclid’s Elements in Latin.

Adelard of Bath has introduced the word « Algorismus » in Latin after his translation of Al Khuwarizmi.
“Mathematics is the art of giving the same name to different things” – Henri Poincaré
the problems addressed by Elie Cartan are among the most important, most abstract and most general dealing with mathematics; group theory is, so to speak, the whole mathematics, stripped of its material and reduced to pure form. This extreme level of abstraction has probably made my presentation a little dry; to assess each of the results, I would have had virtually render him the material which he had been stripped; but this refund can be made in a thousand different ways; and this is the only form that can be found as well as a host of various garments, which is the common link between mathematical theories that are often surprised to find so near”

H. Poincaré
Maurice Fréchet: Metric Everywhere

• Maurice Fréchet made major contributions to the topology of point sets and introduced the entire concept of metric spaces.

• His dissertation opened the entire field of functionals on metric spaces and introduced the notion of compactness.

• He has extended Probability in Metric space

1948 (Annales de l’IHP)
Les éléments aléatoires de nature quelconque dans un espace distancié

Extension of Probability/Statistic in abstract/Metric space
## GSI’17 Sponsors

### Platinum sponsors

- The Alan Turing Institute
- THALES

### Bronze sponsor

- ENAC
- IMAG

### Scientific sponsors

- Société Mathématique de France

### Sponsors

- SMAI’
- GDR MIA
- GDR GeoSto
- MINES ParisTech
- ÉCOLE POLYTECHNIQUE
- Springer
- PSL RESEARCH UNIVERSITY PARIS
GSI’17 Program

• 145 attendees from 37 different countries (France 38%, Germany 9%, Japan 9%, Italy 8%, USA 6%, Belgium 4%, Brazil 3%, Russia 3%, UK 3%, NL 2%, DK 2%, SW 2%, …)

• 101 papers/talks on 3 days (rate: 89% based on 314 reviews)

• 1 Guest Honorary speaker
  • Jean-Michel BISMUT (Paris-Sud University): “The hypoelliptic Laplacian”

• 1 Invited Honorary speaker
  • Daniel BENNEQUIN (Paris-Diderot University): “Geometry and Vestibular Information”

• 3 keynote speakers
  • Alain TROUVE (ENS Paris-Saclay): “Hamiltonian modeling for shape evolution and Statistical modeling of shapes variability”
  • Mark GIROLAMI (Imperial College London): “Riemann Manifold Langevin and Hamiltonian Monte Carlo Methods”
  • Barbara TUMPACH (Lille University): “Riemannian metrics on shape spaces of curves and surfaces”
GSI’17: 19 sessions

• Computational Information Geometry
• Geometrical Structures of Thermodynamics
• Geometry of Tensor-Valued Data
• Probability on Riemannian Manifolds
• Information Structure in Neuroscience
• Geometric Mechanics & Robotics
• Optimization on Manifold
• Geometric Robotics & Tracking
• Probability Density Estimation
• Applications of Distance Geometry
• Statistics on non-linear data
• Shape Space
• Divergence Geometry
• Geodesic Methods with Constraints
• Optimal Transport & Applications
• Monotone Embedding in Information Geometry
• Non-parametric Information Geometry
• Optimal Transport & Applications
• Statistical Manifold & Hessian Information Geometry
GSI’17 Map

MAP OF THE CONFERENCE SITE

V334. Same as Salle des Colonnnes but go up to the third floor. At the top of the stairs go through the door, turn right and then left.

To Salle des Colonnnes (cocktail). Go up to the second floor (you are on the first floor and Salle des Colonnnes is on second floor).

Coffee break & Lunchbox

Toilets

Conference registration

Entrance

Staircase

Boulevard Saint-Michel (street)
# GSI’17 Program

**Tuesday November 7th**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>08h1 - 08h30</td>
<td>Badge withdrawing</td>
</tr>
<tr>
<td>08h30 - 09h00</td>
<td>Opening Session&lt;br&gt;Frédéric Barbaresco, Frank Nielsen, Silvère Bonnabel</td>
</tr>
<tr>
<td>09h00 - 10h00</td>
<td>Keynote Speaker Jean-Michel Bismut&lt;br&gt;The hypoelliptic Laplacian</td>
</tr>
<tr>
<td>10h00 - 10h30</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>10h30 - 12h30</td>
<td>Computational Information Geometry&lt;br&gt;(F. Nielsen/O. Schwander)</td>
</tr>
<tr>
<td></td>
<td>Geometrical Structures of Thermodynamics&lt;br&gt;(F. Gay-Balmaz/F. Barbaresco)</td>
</tr>
<tr>
<td>12h30 - 13h00</td>
<td>Lunch Break</td>
</tr>
<tr>
<td>13h30:00 - 15:30:00</td>
<td>Plenary Session “Probability on Riemannian Manifolds”&lt;br&gt;(M. Arnaudon/A.-B. Cruzeiro)</td>
</tr>
<tr>
<td>15h30 - 16h00</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>16h00 - 18h00</td>
<td>Information Structure in Neuroscience&lt;br&gt;(P. Baudot/D. Bennequin/S. Roy)</td>
</tr>
<tr>
<td></td>
<td>Geometric Mechanics &amp; Robotics&lt;br&gt;(G. de Saxcé/J. Bensoussan/J. Lerbet)</td>
</tr>
<tr>
<td></td>
<td>Optimization on Manifold&lt;br&gt;(P.A. Absil/R. Sepulchre)</td>
</tr>
<tr>
<td>18h00 - 19h00</td>
<td>Keynote Speaker: Daniel Bennequin&lt;br&gt;Geometry and Vestibular Information</td>
</tr>
<tr>
<td>19h00 - 20h00</td>
<td>Welcome cocktail</td>
</tr>
</tbody>
</table>
# GSI’17 Program

## Wednesday November 8th

<table>
<thead>
<tr>
<th>Time</th>
<th>Room</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30-09:00</td>
<td>ROOM POINCARE</td>
<td>Registration Desk</td>
</tr>
<tr>
<td>09:00-10:00</td>
<td>ROOM POINCARE</td>
<td>Keynote Speaker Alain Trouvé. Hamiltonian modeling for shape evolution and Statistical modeling of shapes variability</td>
</tr>
<tr>
<td>10:00-10:30</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>10:30-12:30</td>
<td>ROOM V106 A</td>
<td>Geometric Robotics &amp; Tracking (S. Bonnabel/A. Barrau)</td>
</tr>
<tr>
<td>10:30-12:30</td>
<td>ROOM Y106 A</td>
<td>Probability Density Estimation (S. Said/E. Chevallet)</td>
</tr>
<tr>
<td>10:30-12:30</td>
<td>ROOM L109</td>
<td>Applications of Distance Geometry (A. Mucherino/D. Gonçalves)</td>
</tr>
<tr>
<td>12:30-13:30</td>
<td>Lunch Break</td>
<td></td>
</tr>
<tr>
<td>13:30-15:10</td>
<td>ROOM POINCARE</td>
<td>Plenary Session “Statistics on non-linear data” (X. Pennec/S. Sommer)</td>
</tr>
<tr>
<td>15:10-15:40</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>15:40-17:20</td>
<td>ROOM POINCARE</td>
<td>Shape Space (S. Allasonnière/S. Durrleman/A. Trouvé)</td>
</tr>
<tr>
<td>15:40-17:20</td>
<td>ROOM V106 A</td>
<td>Divergence Geometry (M. Broniatowski/C. Csiszar)</td>
</tr>
<tr>
<td>15:40-17:20</td>
<td>ROOM L109</td>
<td>Geodesic Methods with Constraints (J.-M. Mirebeau/L. Cohen)</td>
</tr>
<tr>
<td>17:20-18:20</td>
<td>ROOM POINCARE</td>
<td>Keynote Speaker Mark Girolami. Riemann Manifold Langevin and Hamiltonian Monte Carlo Methods</td>
</tr>
<tr>
<td>18h20-19h05</td>
<td></td>
<td>Session “Gender Equality - Marie Curie 150th birthday : Women in Science” (Barbara Tumpach)</td>
</tr>
<tr>
<td>20h15</td>
<td></td>
<td>Gala Dinner - Café LE PROCOPE</td>
</tr>
<tr>
<td>Time</td>
<td>Event</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>09h30</td>
<td>Registration Desk</td>
<td></td>
</tr>
<tr>
<td>10h00</td>
<td>ROOM POINCARÉ: Optimal Transport &amp; Applications (J.F. Marrotchino/A. Galichon)</td>
<td></td>
</tr>
<tr>
<td>10h30</td>
<td>ROOM V106 A: Monotone Embedding in Information Geometry (J. Zhang, J. Naudis)</td>
<td></td>
</tr>
<tr>
<td>12h00</td>
<td>Lunch Break</td>
<td></td>
</tr>
<tr>
<td>13h00</td>
<td>ROOM POINCARÉ: Keynote Speaker Barbara Tumpach, Riemannian metrics on shape spaces of curves and surfaces</td>
<td></td>
</tr>
<tr>
<td>14h00</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>14h30</td>
<td>ROOM POINCARÉ: Optimal Transport &amp; Applications (Q. Morigot, J. Bigot, B. Maury)</td>
<td></td>
</tr>
<tr>
<td>15h30</td>
<td>ROOM V106 A: Statistical Manifold &amp; Hessian Information Geometry (M. Boyom, H. Matsuzo, H. Shahid)</td>
<td></td>
</tr>
<tr>
<td>16h30</td>
<td>ROOM POINCARÉ: Closing session by Frédéric Barbaresco, Frank Nielsen and Silvère Bonnabel</td>
<td></td>
</tr>
<tr>
<td>17h00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Jean-Michel Bismut (professor at Paris-Sud Orsay university, member of Académie des Sciences)
His research has been devoted to stochastic control, to the Malliavin calculus, to index theory, and its connections with spectral theory and number theory.

The hypoelliptic Laplacian
If X is a Riemannian manifold, the hypoelliptic Laplacian is a family of hypoelliptic operators acting on X, the total space of the tangent bundle of X, that interpolates between the ordinary Laplacian and the geodesic flow. The probabilistic counterpart is an interpolation between Brownian motion and geodesics.
In the talk, I will explain the construction of the hypoelliptic Laplacian, and describe some of its properties.
Invited Honorary speaker

Daniel Bennequin

Daniel Bennequin (Université Paris 7 - Institut Mathématique de Jussieu). Born 3 January 1952. Graduate from Ecole Normale Supérieure. PHD in 1982 with Alain Chenciner at Paris VII. Then Professor at Strasbourg University. Today Professor at Paris-Diderot University, and member of the IMJ. During the 1980’s he was initiator of contact topology with Y.Eliashberg. During the 1990’s, he worked on integrable systems and geometry of Mathematical Physics. Since 2000 he has been working in Neurosciences (mainly with A.Berthoz, C-d-F, and T.Flash, Weizmann Institute); he made contributions to the study of human movements duration, vestibular information flow and gaze functions during locomotion. His most recent publications are on information topology (with P.Baudot), psychic pain (with M.Bompard-Porte) and labyrinths (with R.David et al.).

Geometry and Vestibular Information

Every complex living entities, as plants, insects or vertebrates, possess visuo-vestibular systems which sense their own motion in space and are crucial for controlling voluntary movements and for understanding space. We will show how the Galilée group guides the visuo-vestibular information flows. Differential Geometry permits to understand the particular forms of the end vestibular organs, that are situated in the inner ear of mammals and birds, from a principle of energy minimization and information maximization. These forms correspond to the surfaces of divisors of real (resp. imaginary) twisted curves, for the epithelia which sense linear accelerations (resp. rotations) of the head. The Hodge-DeRham theory, applied to the labyrinths volume of vertebrates, permits to explain how a complex fluid movement is transformed in six solutions of ordinary second order differential equations, for registering the head rotations in space. Combined with an original and delicate method of analysis of the membranous tissues, invented by Romain David, this allows for the first time, to describe the precise relation between the structure and the function of the labyrinth.
Keynote speaker
Alain Trouvé

Alain Trouvé (ENS Paris-Saclay, CMLA Department). Alain Trouvé, bachelor’s degree from Ecole Normale Supérieure Ulm, a doctor of the University of Orsay, began his career as “agrégé préparateur” at the ENS Ulm before becoming a professor at the University of Paris13 (1996) and then at ENS Cachan (2003). Alain Trouvé is currently Professor at the Center of Mathematics and Their Application (CMLA) at ENS Paris-Saclay. He did his Ph.D. in Stochastic Optimization and Bayesian Image Analysis under the supervision of Robert Azencott. His main research interests are computational vision and shape analysis with a particular emphasis on the use of Riemannian geometry and infinite dimensional group actions driven by applications in computational anatomy and medical imaging.

Hamiltonian modeling for shape evolution and Statistical modeling of shapes variability

In his book "Growth and Forms", first published in 1917, d'Arcy Thompson, a Scottish naturalist and mathematician, develops his theory of transformations, whose central idea is the morphological comparison of anatomies through groups of transformations of Space that act on it. This idea, a century later, remains at the heart of contemporary geometric approaches of quantitative comparison of forms but in a very different mathematical and technological context. In this talk, we present the ideas and techniques that underlie the "diffeomorphometric" approach developed in the context of computational anatomy, its links with infinite dimensional Riemannian geometry, the theory of control And Hamiltonian systems, but also the dimension reduction tools that underlie the algorithms used in the analysis of sub-varieties and make them effective. We will also present new prospects for extension on the geometric-functional objects that combine geometric and functional information and pose new and numerous challenges.
Riemann Manifold Langevin and Hamiltonian Monte Carlo Methods

The talk considers Metropolis adjusted Langevin and Hamiltonian Monte Carlo sampling methods defined on the Riemann manifold to resolve the shortcomings of existing Monte Carlo algorithms when sampling from target densities that may be high dimensional and exhibit strong correlations. The methods provide fully automated adaptation mechanisms that circumvent the costly pilot runs that are required to tune proposal densities for Metropolis–Hastings or indeed Hamiltonian Monte Carlo and Metropolis adjusted Langevin algorithms. This allows for highly efficient sampling even in very high dimensions where different scalings may be required for the transient and stationary phases of the Markov chain. The methodology proposed exploits the Riemann geometry of the parameter space of statistical models and thus automatically adapts to the local structure when simulating paths across this manifold, providing highly efficient convergence and exploration of the target density. The performance of these Riemann manifold Monte Carlo methods is rigorously assessed by performing inference on logistic regression models, log-Gaussian Cox point processes, stochastic volatility models and Bayesian estimation of dynamic systems described by non-linear differential equations. Substantial improvements in the time-normalized effective sample size are reported when compared with sampling approaches.
Riemannian metrics on shape spaces of curves and surfaces

The aim of the talk is to give an overview of geometric tools used in Shape Analysis. We will see that we can interpret the Shape space of (unparameterized) curves (or surfaces) either as a quotient space or as a section of the Preshape space of parameterized curves (or surfaces). Starting from a diffeomorphism-invariant Riemannian metric on Preshape space, these two different interpretations lead to different Riemannian metrics on Shape space. Another possibility is to start with a degenerate Riemannian metric on Preshape space, with degeneracy along the orbits of the diffeomorphism group. This leads to a framework where the length of a path of curves (or surfaces) does not depend on the parameterizations of the curves (or surfaces) along the path. Of course the choice of the metrics has to be motivated either from the applications or from their mathematical behaviour. We will compare some natural metrics used in the literature.
On the occasion of the 150th Marie Curie Birthday (November 7th 1867) Barbara Tumpach will animate a session “Women in Science”, November 8th from 18h20 to 19h05 in Poincaré Amphi, with Nina Miolane and Alice Le Brigant.

We have coupled this session with two other events, November 8th:
- during 10.00-1030 Coffee Break: Natacha Henri’s book dedication on "Sisters in Science, Marie Curie and Bronia Dluska"
  https://www.youtube.com/watch?v=2JKHpgHHoAM
- during 12.30-13.30 Lunch break: exhibition on “Women and Science in the Heritage Funds” at the Ecole des Mines Library
  http://www.mines-paristech.fr/Actualites/Exposition-Les-femmes-et-la-science/3086

10 minutes walk from Ecole des Mines, we invite you to visit "Marie Curie 150th Birthday Exhibition" at PANTHEON (that will start November 8th) and Curie Museum:
  http://musee.curie.fr/visiter/evnements/marie-curie-150e-anniversaire
150th Marie Curie Birthday (November 7th 1867)

For GSI’17, Exhibition visit November 8th during 12.30-13.30 Lunch break

Original edition of Marie Curie's thesis on radioactive substances of 1903

http://www.mines-paristech.fr/Actualites/Exposition-Les-femmes-et-la-science/3086

Mines Exhibition on “Women and Science in the Heritage Funds” at the Ecole des Mines Library

For GSI’17, Natacha Henri (Marie Curie Biographer) will dedicate her book on "Sisters in Science, Marie Curie and Bronia Dluska“, November 8th during 10.00-1030 Coffee Break

https://www.youtube.com/watch?v=2JKHpgHHoAM
Exhibition « Marie Curie a women in PANTHEON” (Panthéon, opening November 8th)

http://musee.curie.fr/visiter/evenements/marie-curie-150e-anniversaire
GSI’17 Gala Dinner
Café LE PROCOPE since 1686
When the French comedy theatre was set up not far from the café in 1689, the Procope quickly became a place for the rendez-vous of literary and theatre critics, writers and philosophers. It was also at the Procope where the idea to create an encyclopedia took place during a conversation between Diderot and d’Alembert. Meetings and exchanges between regulars such as Voltaire, Rousseau, etc. gave birth to the liberal and progressive ideas of the 18th century.
Digital, Collaborative & Critical Edition of Diderot-d’Alembert Encyclopedia


http://enccre.academie-sciences.fr/encycledie/

Nov. 14th, D’Alembert : tricentenaire du mathématicien et philosophe des Lumières
Last Publications on Geometric Science of Information

- **Introduction to Symplectic Geometry**
  Jean-Louis Koszul
  Science Press, Beijing (1986)
  (in Chinese)
  (with reference to Souriau work)
  Translation by SPRINGER in 2018
TGSI’17 Videos/slides available

http://forum.cs-dc.org/category/94/tgsi2017

Special Issue "Topological and Geometrical Structure of Information", Selected Papers from CIRM conferences 2017"

http://www.mdpi.com/journal/entropy/special_issues/topological_geometrical_info
The main topics and sessions of the conference cover:

- Physics: classical Thermodynamics and Quantum
- Statistical physics and Bayesian computation
- Geometrical science of information, topology and metrics
- Maximum entropy principle and inference
- Kullback and Bayes or information theory and Bayesian inference
- Entropy in action (applications)

The inter-disciplinary nature of contributions from both theoretical and applied perspectives are very welcome, including papers addressing conceptual and methodological developments, as well as new applications of entropy and information theory.
The "calculation of probabilities" began four years after the death of René Descartes, in 1654, in a correspondence between Blaise Pascal and Pierre Fermat. We do not find in Pascal's writings, the words of "Doctrine des chances", or "Calcul des chances", but only "Géométrie du hasard" (geometry of chance). In 1654, Blaise Pascal submitted a short paper to "Celeberrimae matheseos Academiae Parisiensis" with the title "Aleae Geometria" (Geometry of Chance), that was the seminal paper founding Probability as a new discipline in Science.

Blaise Pascal was also the inventor of computer with his "Pascaline" machine. The introduction of Pascaline marks the beginning of the development of mechanical calculus in Europe. It was Charles Babbage who conceived an analytical machine from 1834 to 1837, a programmable calculating machine which was the ancestor of the computers of the 1940s, combining the inventions of Blaise Pascal and Jacquard’s machine, with instructions written on perforated cards.
From PASCALINE Machine to HPC or Geometric Integrating Machines

Geometric Machines

Geometric, Variational, Symplectic & Polysymplectic Integrators
(Intrinsic Computation without coordinates, conservation of symplectic 2-form)

Pascaline
Jacquard Loom
Babbage Analytic Machine

High Power Computing

Descartes computation with coordinates
2018: 250\textsuperscript{th} Birthday of Jean-Baptiste-Joseph Fourier

- A special Issue will be organized for this 250\textsuperscript{th} birthday in “From Physics to Information Sciences and Geometry” conference.
- A MDPI special issue will explore modern topics related to Fourier Analysis and Heat Equation.
- Classical Fourier commutative harmonic analysis is restricted to functions defined on a topological locally compact and Abelian group G. Modern developments of Fourier analysis during XXth century have explored generalization of Fourier and Fourier-Plancherel formula for non-commutative harmonic analysis, applied to locally compact non Abelian groups, by geometric approaches based on “orbits methods”.
- The name of Joseph Fourier is also inseparable from the study of mathematics of heat. Modern research on Heat equation explores extension of classical diffusion equation on Riemannian and sub-Riemannian manifolds. In parallel in Geometric Mechanics, Geometric Theory of Heat has been explored to study relativistic models of a dissipative continuum that complies with the laws of both mechanics and thermodynamics.