



**Department of Mechanical Engineering
Russell Severance Springer Colloquium**
presents

**“Data Driven” or “Theory Driven”?
An Epistemological Reflexion Motivated by the Need
of Designing Exotic Metamaterials**

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**Tuesday, January 30, 2018
4:00 p.m.
3110 Etcheverry Hall**

Coffee & cookies will be served.

ABSTRACT

One of the most advanced frontiers in modern technology concerns the design and the realisation of materials which have innovative performances and are not yet observed in nature. The invention and diffusion of 3D printers made possible the construction of (meta)materials with very complex and highly organised internal microstructures. Even if such microstructures are built by using an isotropic and homogeneous material with perfectly standard behaviour, the resulting metamaterial may have exotic overall performances. The scientific problem of greater interest in this context is the problem of synthesis of a metamaterial whose physical characteristics have been chosen “a priori”. But: how can one predetermine the properties of a metamaterial? To answer to this question one can decide to choose the evolution equations which should govern the behaviour of the meta material to be invented and only in a second step he tries to synthesise the microstructure constituting it. This procedure is not new: in the Forties of XX century this procedure was used for synthesising analogical computers and it had a great impact in the technologies of that époque. Indeed a whole research group (whose leader was Kron) in General Electric for more than 20 years was completely devoted to this kind of researches. The part of the theory of circuits developed by Kron has been often considered as obsolete and actually has been nearly forgotten: however it is being nowadays revived in a completely different context. In the theory of the synthesis of metamaterials we are not looking for the equations needed to describe the phenomena occurring to a given physical system, instead we look for a physical systems whose phenomenology is described by the equations which we have chosen “a priori”. A suitably deep and careful analysis of the epistemological questions which are implied by such a change of paradigm seems now necessary. It seems to us that they were not yet addressed with sufficient systematic generality: we however are confident that once more the ancient and powerful vision presented by Archimedes of Syracuse, and developed in more recent times by Popper and Kuhn, will supply us a strong guidance not only in our scientific understanding of reality but also towards outbreking technological progresses. Actually one cannot probably solve efficiently any serious scientific or technological problem with purely “data driven” methods. Therefore we do not believe that simply elaborating a great amount of data one can solve the problem of synthesis of useful metamaterials. Nobody will find useful meta material by randomly choosing microstructures and then checking which is the behaviour of chosen microstructures. Moreover any blind elaboration of data may lead to any reasonable result in a reasonable time span. Data must be elaborated by an intelligence: may it be human or artificial, this seems not really important. But a form of intelligence is needed. Actually also in the design of metamaterials “theory driven” analysis may lead to an effective understanding and mastering of technological applications. It is surely interesting, in the most general epistemological debate, the point of view of a mechanician which invested many years of activity in the conception, design and construction of innovative metamaterials. Also in this specific context the change of scientific paradigm needed to efficiently design metamaterials is clearly incompatible with a vision which regards science as an activity based on the brutal gathering, not driven by any rationale and not organised, of data which have to be only merely treated numerically. To describe the process of birth of a star, the seismic response of a complex structure or the design process of a resilient structure ready to resist to heavy seismic actions, or also to synthesise a novel meta material these are all research activities which must be guided by an Archimedean epistemological vision. One must start with a theory, i.e. a logically consistent series of conjectures (otherwise called postulates), and by using this theory he must get predictions to be verified by experimental evidence. Data must be organised by means of a theory, but they can never produce a theory by brutal induction. Naive inductivism must be replaced by a sophisticated form of falsificationism: in his “On the Method” Archimedes already suggested us such a methodology.