# METAPHORS AND MYTH: THE ROOTS OF ANALOGICAL STRUCTURES IN MACROSCOPIC PHYSICAL SCIENCE

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Hans U. Fuchs Center for Narrative in Science, Winterthur, Switzerland and Department of Education and Humanities University of Modena and Reggio Emilia, Italy A PRELIMINARY Macrosco SUMMARY IN THE structure FORM OF SOME They are CLAIMS small-sca substance scale per wind, fire

Macroscopic physical science exhibits **imaginative** structures known from conceptual metaphor theory. They are created by metaphorically projecting small-scale image schemas (polarity, scale, substance, container, path...) upon the mediumscale perceptual gestalt of forces of nature (water, wind, fire, ice, food, light, motion...).

The perception and conception of forces of nature is an age old affair—we find these structures in language all the way back to **mythic culture**. In other words, much of the **conceptualization** found in modern continuum pyhsics is of **mythic origin**.

Since different forces (fluids, electricity, heat, substances, motion, gravity) are conceptualized in terms of the same basic metaphoric projections, they are rendered similar to the human mind—we see them as having analogous structure.

## TABLE OF CONTENTS

- 1. Linguistic phenomena
  - 2. Forces of nature and mythic thought
- 3. Imaginative structures in macroscopic physical science
- 4. Analogy in macroscopic physical science
  - Summay
  - References



DIAGRAMMATIC VIEW OF NEWCOMEN'S ATMOSPHERIC OR FIRE ENGINE (1712)

## 1. LINGUISTIC PHENOMENA IN MACROSCOPIC PHYSICAL SCIENCE - HEAT

Examples of expressions involving heat. There are no examples of literal use of language:

- All bodies *contain heat*....
- How do you *collect heat* in a passive solar house?
- This means *heat flows* "downhill" from hot to cold.
- ... *heat is an agent* of vast importance in chemical reactions and engineering processes
- Law of the dependence of the active *force of heat* upon the tempera... (Clausius)
- This exterior *heat lets* the crust become crispy
- *Heat makes* me dizzy...
- Clouds and storms follow the warm water, *pumping heat* and moisture high into the atmosphere...
- Heat must *balance* cold...

*Expressions for heat use the following schematic constructs:* 

- Container, store, hold, accumulate; lack of, abundance of; collect
- ☐ Flow, transport, extract emit/absorb, exchange; heat moves
- **¬** Balance (law of balance of...)
- **¬** Use, produce, generate heat
- Balance of heat and cold, hot and cold; thermal tension
- Power, force of heat
- ☐ Heat is an agent: Heat causes, drives, makes, counteracts, lets, balances
- Heat is a patient: Pump, force, make, counteract, block, hold (back), enable, prevent, oppose, let/allow heat

<sup>—</sup> Heat is a powerful agent...

## 1. LINGUISTIC PHENOMENA IN MACROSCOPIC PHYSICAL SCIENCE - A NARRATIVE...

## Sadi Carnot (1824): Réflexions sur la puissance motrice du feu

Every one knows that *heat* can produce motion. That it *possesses vast motive-power* no one can doubt, in these days when the steam-engine is everywhere so well known. *To heat also are due* the *vast movements* which take place on the earth. It causes the *agitations of the atmosphere*, the ascension of clouds, the fall of rain and of meteors, the *currents of water* which channel the surface of the globe, .... Even *earthquakes and volcanic eruptions* are the result of heat.

According to established principles at the present time, we can compare with sufficient accuracy the motive *power of heat* to that of a *fall of water* [...]. The motive power of a fall of water depends on its height and on the quantity of the liquid; the motive power of heat depends also on the *quantity of caloric* used, and on what may be termed, on what in fact we will call, the *height of its fall*, that is to say, the difference of temperature of the bodies between which the *exchange of caloric* is made.





## 2. FORCES OF NATURE AND MYTH - ORIGIN AND EXAMPLES

In the previous examples, we recognize a recurring *medium scale* cognitive structure  $\rightarrow$  Force of Nature.

This structure has *perceptual origin*  $\rightarrow$  the *Gestalt of Force*.

#### Examples...

#### Heat as a force of nature

Very basically, we perceive **HEAT** as a unit/gestalt. We know when we have a thermal experience...

#### Examples of forces of nature

Water, wind, light, fire, cold, food, motion, substances...

#### Psychological and social forces

Justice, knowledge, anger, love, *music* (Johnson, 2007)...





## 2. Forces of Nature and Myth – Origins in Mythic Culture

#### When Heaven and Earth Were Created

*Creating and maintaining* TENSIONS *so that* MAAT *can* FLOW *and life go on...* 



In Egyptian mythology, Shu (wind) separates Nut (sky) from Geb (Eath). The sky needs to be supported let it falls down upon Earth.

With the separation of sky and Earth, an *ur-tension* is created that maintains processes. There is a *flow from higher to lower level* that drives other processes...

This mythic conceptualization of an image of nature and natural processes sounds very modern—or maybe conceptualizations in physics are mythic.

http://www.civilization.ca/civil/egypt/images/reli28b.jpg

## 2. Forces of Nature and Myth – Imaginative Structure

#### THE PERCEPTUAL GESTALT OF FORCES OF NATURE

FIGURATIVE STRUCTURE OF FORCES (basic aspects)

- Intensity (quality, derived from polarities; tension as differences of intensity)
- **Substance** (quantity)
- **Power** (as a measure of causation)

MACROSCOPIC PHYSICS IS A COLLECTION OF THEORIES OF FORCES OF NATURE



## 3. IMAGINATIVE STRUCTURES IN MACRSOCOPIC PHYSICAL SCIENCE



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4. ANALOGY IN MACRSOCOPIC PHYSICAL SCIENCE

Laws of balance in continuum physics

Amount of  
substance
$$\frac{\partial \rho_n}{\partial t} + \frac{\partial}{\partial x} (j_{n,cond} + j_{n,conv}) = 0 + \pi_n$$
Entropy $\frac{\partial \rho_s}{\partial t} + \frac{\partial}{\partial x} (j_{s,cond} + j_{s,conv}) = \sigma_s + \pi_s$ Momentum (in a  
single dimension...) $\frac{\partial \rho_p}{\partial t} + \frac{\partial}{\partial x} (j_{p,cond} + j_{p,conv}) = \sigma_p + 0$ 

## 4. ANALOGY IN MACRSOCOPIC PHYSICAL SCIENCE

## Constitutive relations in continuum physics



SUMMARY: ROOTS OF ANALOGICAL STRUCTURES AND REASONING IN MACROSCOPIC PHYSICS



- → Physical processes are percieived (and classified) as *Forces of Nature*
- Force is a *perceptual unit* (gestalt) that, when analyzed, shows three main aspects: those of *intensity* (tension), *quantity* or size (extension), and *power*. All three are *imaginative structures*. Relations between these aspects are *understood metaphorically* through the *projection of additional image schemas*.
- Forces are rendered imaginatively through the use of (conceptual) metaphors—there is a *metaphoric network* that *structures our understanding of a force*
- All forces are structured in basically the same manner; this makes them similar to our mind which allows us to use *analogical reasoning*

SUMMARY: WEB OF IMAGINATIVE STRUCTURES FOR CONCEPTS (TEMPERATURE)



Metaphors and Myth in Physical Science SUMMARY: WEB OF IMAGINATIVE STRUCTURES FOR CONCEPTS (HEAT) CONCEPTUAL MAP FOR HEAT BASED UPON THE HEAT AS FORCE OF NATURE SCHEMA **Continuum Thermodynamics Caloric** is the thermal fluid quantity that is stored in bodies, can be transported and can be produced ( $\rightarrow$  entropy). Power of Heat is equivalent to LARGE-SCALE STORY TIME stress power. HEAT AS AN AGENT **SCHEMA PERCEPTUAL UNIT:** AMONG OTHER AGENTS HEAT AS AGENT IN ACTING AND SUFFERING PROCESS AGENCY IN A STORY-WORLD STORY-WORLD CALORIC THERMAL POWER TEMPERATURE LINGUISTIC FORMS CURRENT PRODUCTION RATE making energy thermal level OF CALORIC (SYMBOLIC UNITS) OF CALORIC power available thermal of heat landscape thermal **R**ELATING TO HEAT using thermal fluid / (3) FORMAL thermal charge energy tension imagistic MEDIUM-SCALE CAUSATION: HEAT **PERCEPTUAL UNIT:** FORCE DYNAMIC PROCESS AS FORCE OF NATURE SCHEMAS FORCE OF NATURE TIME SMALL-SCALE POWER OF HEAT (2) CALORIC<sup>(1)</sup> HOTNESS PERCEPTUAL UNITS Linguistic forms: (1) Caloric (thermal charge) (2) Power of Heat (3) **Energy** related concepts apply symbolic units or There is no direct perception of Indirect perception: Heat causes equally to all other forces of linguistic signs (soundquantity of heat responsible for other things to happen or is made nature: fluids, electricity, chemical concept pairings) the formation of this image. to happen by other things. processes, motion, gravity.

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