# Idealization in Scientific Explanation

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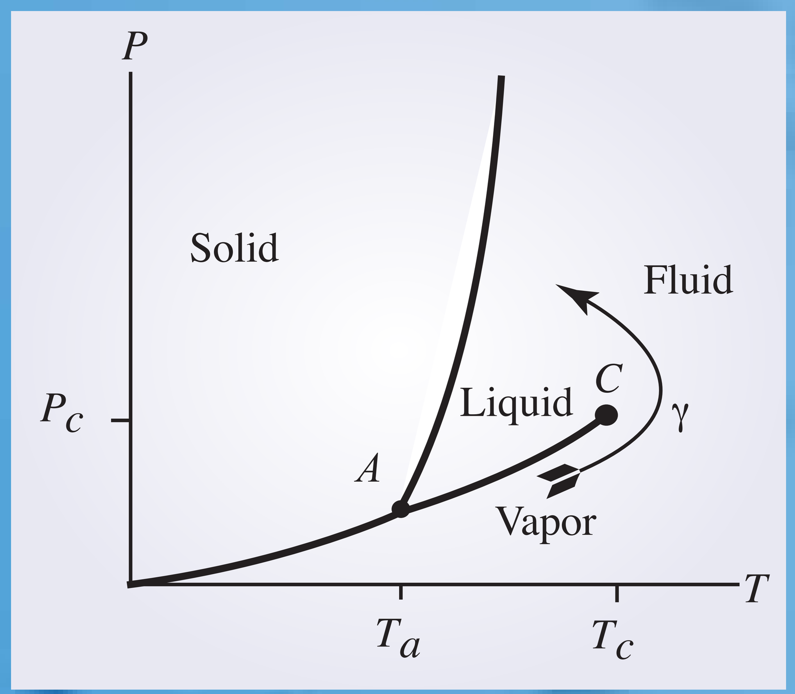
## Phase Transitions

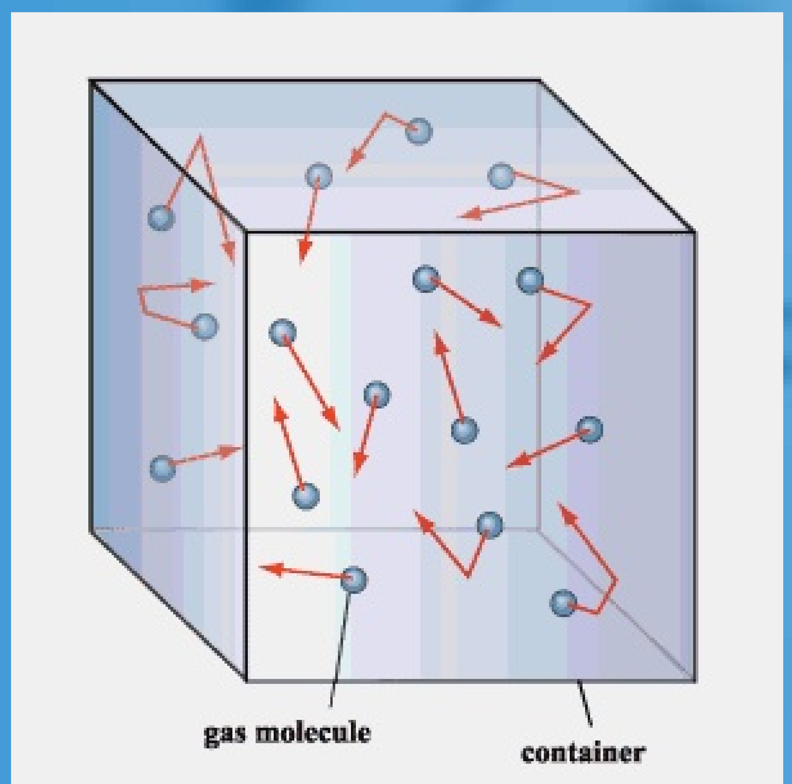


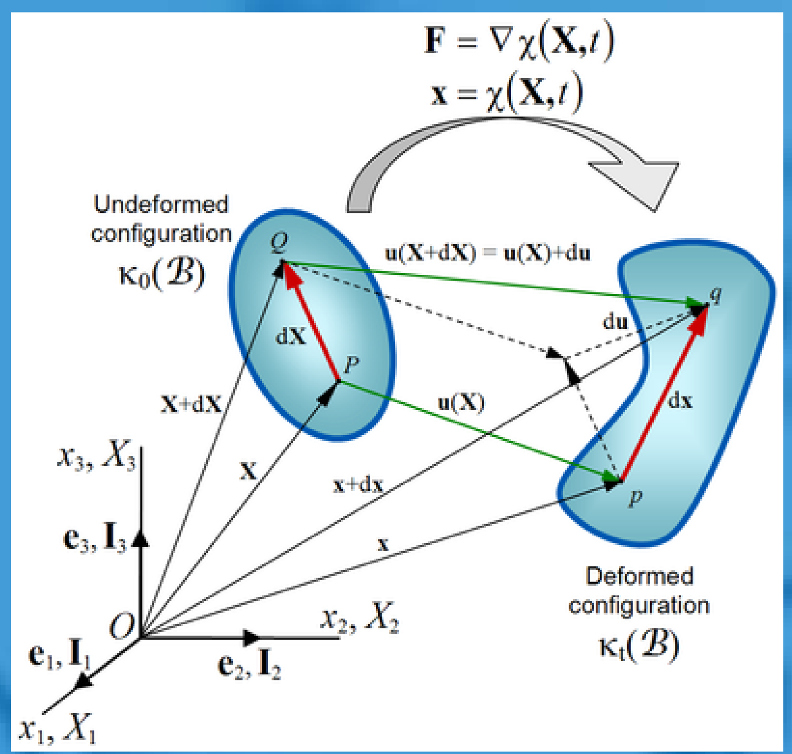

The critical behavior of a fluid is best characterized by its order parameter:

$$\Psi = \rho_{liq} - \rho_{vap} \sim \left|\frac{T - T_c}{T_c}\right|^{\beta}$$

$\beta$ is the same for many fluids and magnets. It is **universal**.

Discrete and continuous representations of physical media:




## Types of Explanation

**Why-Questions I: Why does this particular instance of the pattern appear?**

**Why-Questions II: Why is it that there is a pattern that remains stable under various changes?**

We can explain (in sense II) why such patterns are to be expected if we can show that many of the multitudes of details that are different in each instance do not matter.

## Levels of Explanation

In many instances, the explanations of physical phenomena based on microscopic details provided by "fundamental" theories are incomplete. Such cases require that we ignore microscopic details and focus on a phenomenological account; this is accomplished, mathematically, by **asymptotic reasoning**.

## Breaking Drops

Droplets always break with the same shape. Moreover, secondary drop breaks with same shape. The explanation of this universal phenomenon requires an infinite idealization.

## Types of Idealization

The understanding many phenomena *requires* idealization; *e.g.*, our understanding of universal phenomena often depends upon treating a discrete system of particles as a continuous blob. Idealization in mathematical modeling demands appeal to features we know to be false to obtain an explanation.

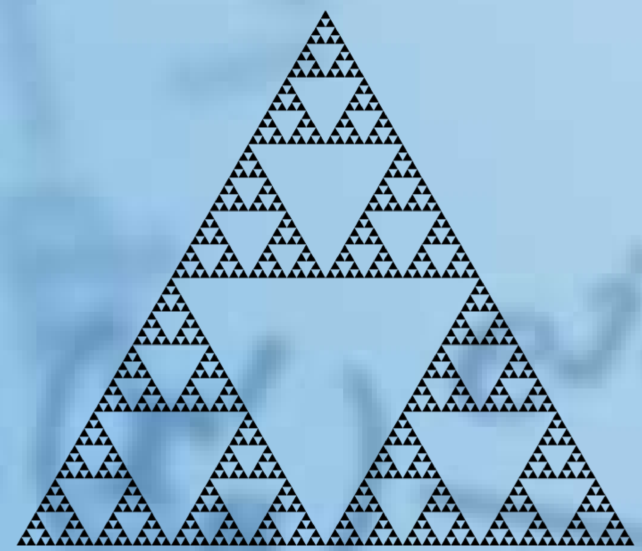
They are of two kinds:

**Galilean:** They are eliminable, de-idealizable.

**Non-Galilean:** They are explanatorily essential, and cannot be eliminated.

Our contention is that non-Galilean should be taken seriously.

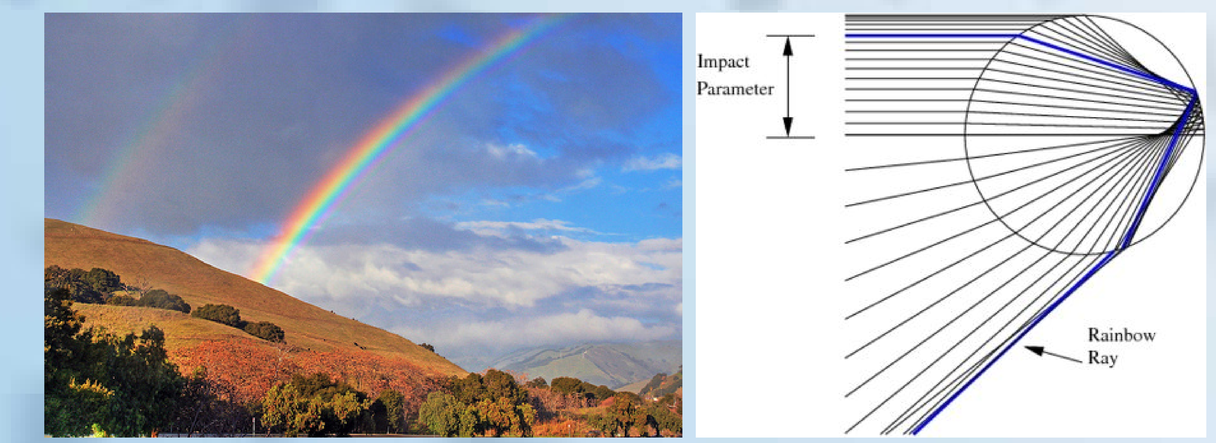
## Sierpinski triangle



(1) Randomly pick a point in the triangle. (2) Randomly pick a vertex. (3) Move half way towards it. (4) Back to 2.

## Theory of Rainbows

Rainbows appear with the same shape and patterns of spacings and intensities of their bows, regardless of the nature of the storm that may effect the shape of the water drops. This universality in pattern cannot fully be explained solely in terms of the "fundamental" wave theory of light. For such an explanation one requires reference to properties of families of light *rays*.



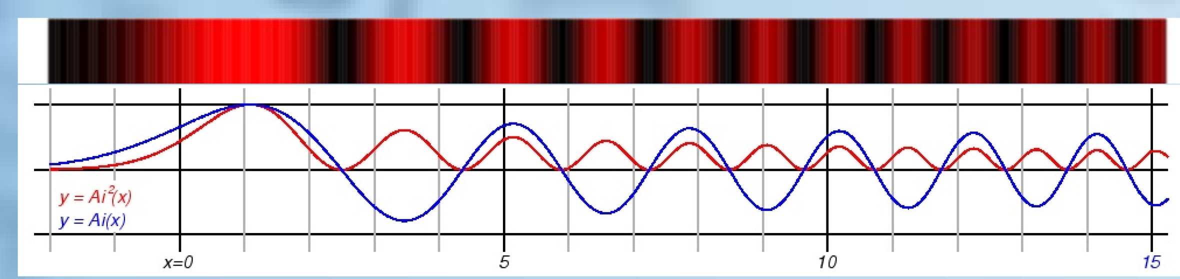

A theory, "catastrophe optics" (that has both wave- and ray-theoretic components) provides the complete explanation of the rainbow patterns by enabling one to derive the so-called critical exponents in the following scaling formula.

$$\phi(R_i) = k^{\beta}\psi(k^{\sigma_i}R_i), \qquad k \to \infty$$

$\beta = 1/6$ and $\sigma_1 = 2/3$.

Catastrophe optics, describes the asymptotics regime between ray- and wave-optics.

$$Ai(x) = \frac{1}{\pi}\int_0^{\infty} \cos\left(\frac{t^3}{3} + xt\right) dt$$




Many phenomena pose interesting "fundamental" questions for both physics and philosophy of science. Understanding and explanation often seem to require non-Galilean, essential idealizations. But idealizations are false. This fact suggests that we need to give up on the view that truth is a necessary condition for explanation.