# Idealization in Scientific Explanation


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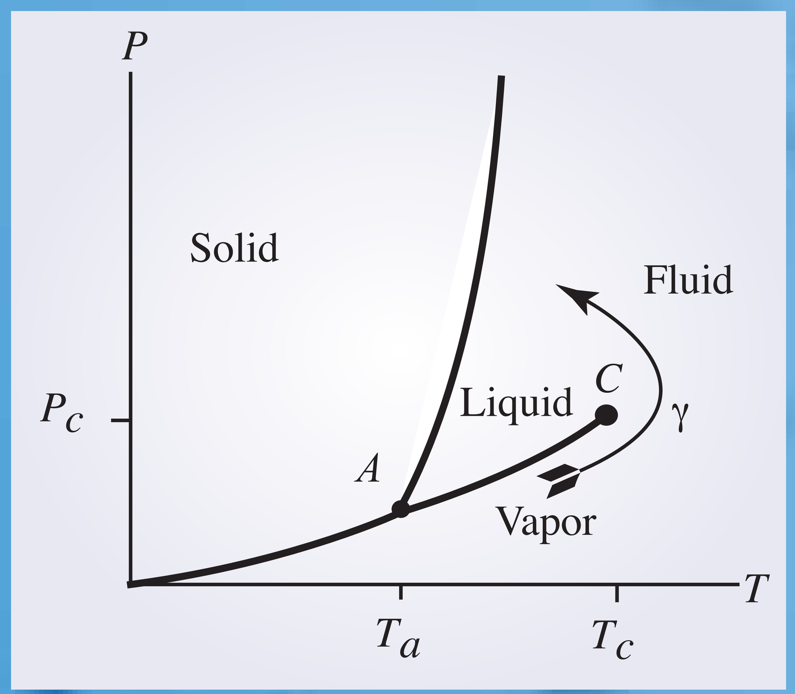
## Phase Transitions

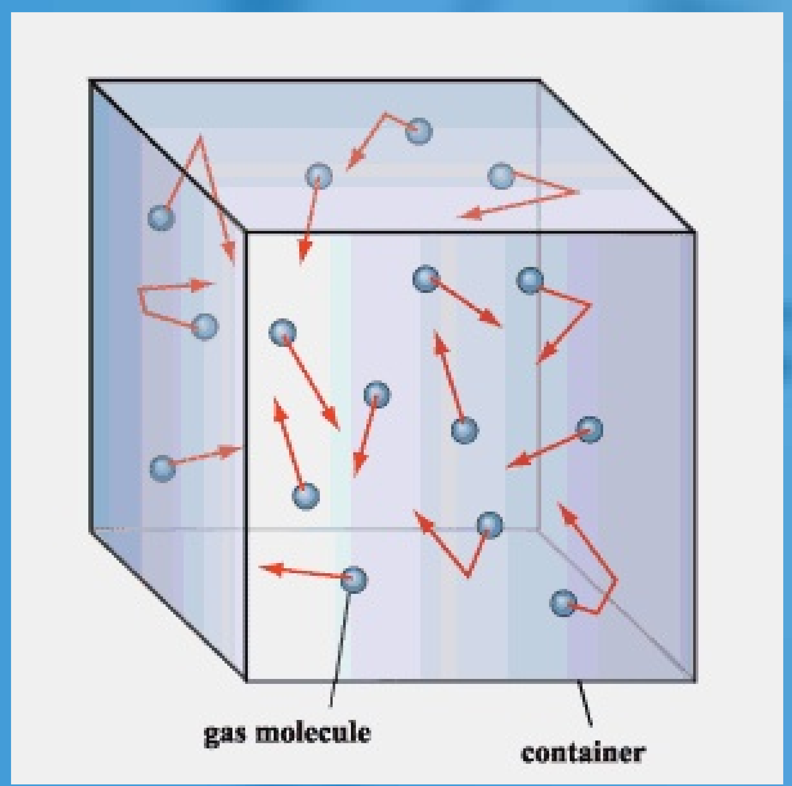


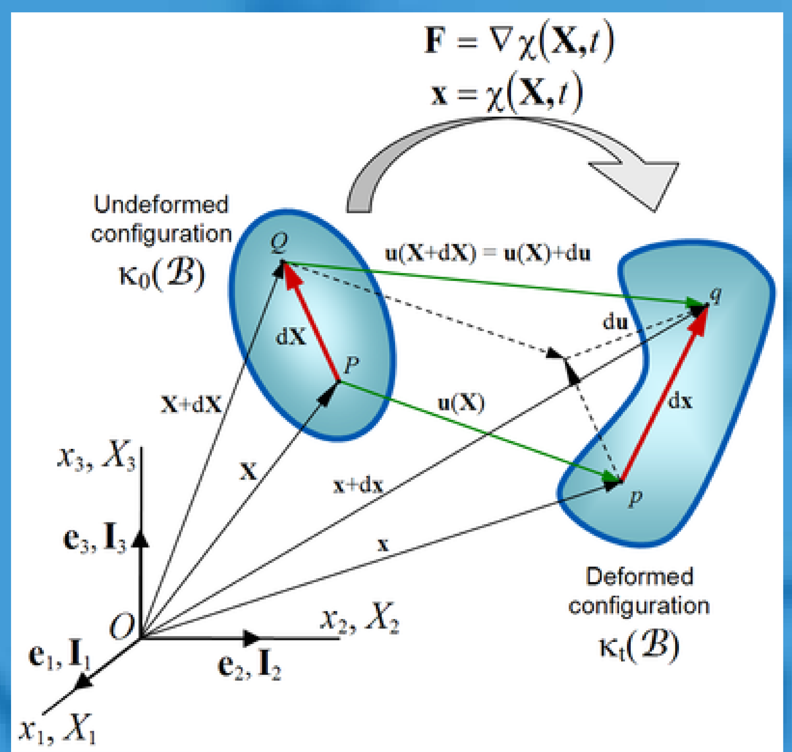

The critical behavior of a fluid is best characterized by its order parameter:

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

$\beta$ 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 the phenomenological dimension; this is mathematically accomplished by **asymptotic reasoning**.

## Breaking Drops

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

## Types of Idealization

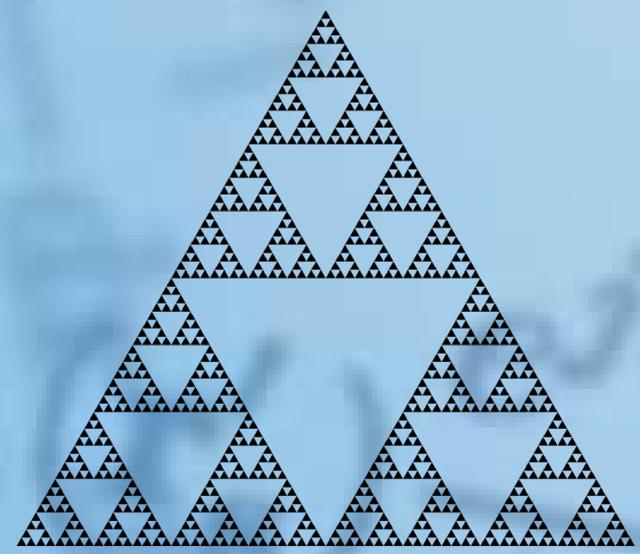
Understanding many phenomena demands that we idealize; *e.g.*, many universal phenomena demand that we suppose that a discrete system of particles is in fact a continuous blob. Idealization is a modeling method relying on features we know to be false to obtain an explanation. They are of two kinds:

**Galilean:** They are eliminable, reversible.

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

we mad add something here, or above...

## Sierpinski triangle

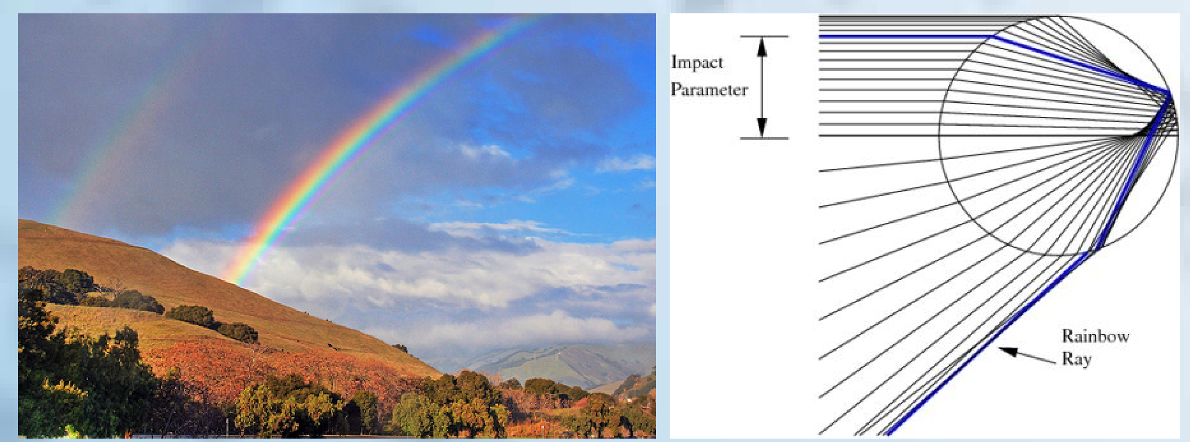


(1) Randomly pick a point in the triangle. (2) Randomly pick a vertex. (3) Move half way towards it. (4) Back to 2.

## Theory of Rainbows

The explanation of universal patterns of spacings and intensities in rainbow requires a theory between the common theories, *i.e.*, ray optics and wave optics.

The wave theory of light does not explain the pattern invariance with respect to the shape of water droplets.



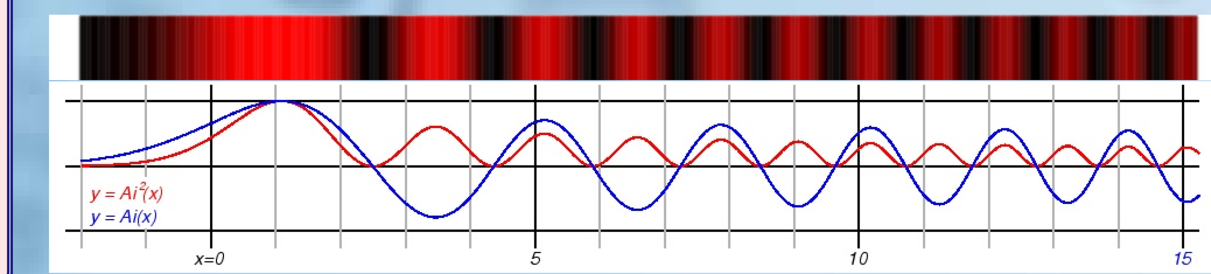

Ray theory, in which shortwave length nears zero, explains this invariance by means of scale factors:

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

$\beta = 1/6$ and $\sigma_1 = 2/3$, universally. However, it fails to account for supernumerary bows. If we allow internal reflection, the account is more accurate, but it still fails to account for bows due to interference.

We need catastrophe optics, which is describing 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. Questions of explanation and understanding often seem to require non-Galilean 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.