Dynamics of the Solar Wind: Parker's Treatment and the Laws of Thermodynamics

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Zeroth Law of Thermodynamics

$A \leftrightarrow B$ and $B \leftrightarrow C$

Then…

$A \leftrightarrow C$

But the law also implies that temperature is an intensive property.

The temperature of an object cannot depend on extensive properties which in combination do not yield an intensive property.

Intensive versus Extensive Properties

Intensive Properties	Extensive Properties
Temperature	Mass
Pressure	Energy
Density	Enthalpy
Concentration	Entropy
Specific Volume	Volume
Color	Heat Capacity

Intensive versus Extensive Properties

The concept of intensive and extensive properties is so important that Peter Landsberg wanted to establish it as

The 4th Law of thermodynamics

P.T. Landsberg, Thermodynamics with Quantum Statistical Illustrations, Interscience Publishers, New York, 1961, p. 142.

Equations: Intensive versus Extensive Properties

"If one side of an equation is extensive (or intensive), then so must be the other side"

S.G. Canagaratna

Intensive and Extensive Properties: Underused Concepts,
J. Chem. Educ., 1992, v. 69, no. 12, 957-963.

Lesson From the Ideal Gas Law

$$\mathrm{PV} = \mathrm{nRT} \;\rightarrow\; P = \frac{nRT}{V}\text{ , since: } n = \frac{\mathrm{M}}{M}\text{ then, } \rightarrow P = \frac{\mathrm{M}RT}{M\mathrm{V}}$$

$$\text{since: } \rho_o = \frac{\mathrm{M}}{\mathrm{V}} \quad\text{and:}\quad R_s = \frac{\mathrm{R}}{M} \rightarrow P = \rho_o R_s T$$

P = pressure (intensive)
T = temperature (intensive)
M = mass (extensive)
V = volume (extensive)
ρ_o = density (intensive) = mass/volume
n = number of moles (extensive) = mass/molar mass = M/*M*
R = universal gas constant (constant)
R_s = specific gas constant (constant) = universal gas constant/molar mass
T = temperature (intensive)
M = molar mass (constant)

Parker's Temperature

$$\lambda = GM_SM_H/2k_Ba\,T_o$$

$$T_o = GM_SM_H/2k_Ba\lambda$$

λ = dimensionless parameter (number)
G = universal constant of gravitation (constant)
M_S = Mass of the Sun (extensive)
M_H = Mass of a proton (constant)
k_B = Boltzmann's constant (constant)
a = radial distance to the base of the corona from which the solar wind originates (neither intensive nor extensive)

(see p. 667 in: E. N. Parker, Dynamics of the Interplanetary Gas and Magnetic Fields. Astrophysical J. 1958, v. 128, 664-676).

Parker's Temperature

$$T_o = GM_SM_H/2k_Ba\lambda$$

As a result, the temperature advanced by Eugene Parker is non-intensive, contrary to the requirement of the laws of thermodynamics.

This illustrates that the solar winds could not have arisen through the thermal expansion of coronal gas as is currently believed.

A solution to this problem must include the realization that the Sun is comprised of condensed matter and that the corona possesses both condensed matter and gaseous plasma.

Robitaille P.-M.L. Forty Lines of Evidence for Condensed Matter – The Sun on Trial: Liquid Metallic Hydrogen as a Solar Building Block. Prog. Phys. 2013, v. 4, 90-142.