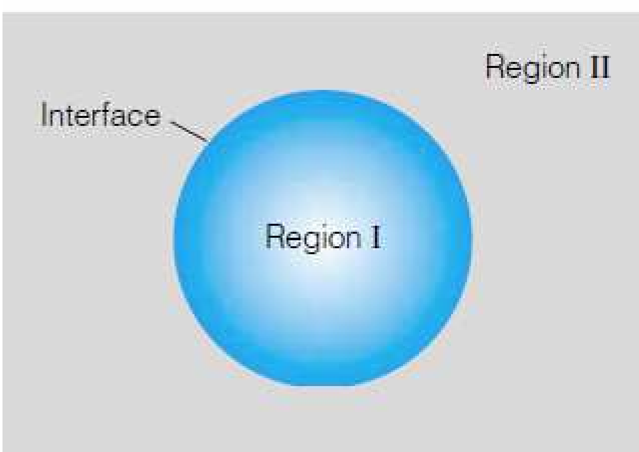
Surface tension

Masatsugu Sei Suzuki
Department of Physics, SUNY at Binghamton

(Date: January 17, 2019)

1. Introduction

Liquid	Temperature (°C)	Surface tension, γ (dyn/cm or erg/cm^2)[a]
Acetic acid	20	27.8
Acetone	20	23.7
Bromine	20	41.5
Chloroform	20	27.1
Diethyl ether	20	17.0
Ethanol	20	22.8
Ethyl ether	50	13.5
Glycerine	20	63.4
Helium	−270	0.24
Mercury	25	485.5
Water	0	75.6
Water	10	74.22
Water	20	72.75
Water	60	66.18
Water	100	58.9



We consider a droplet of liquid as shown in Fig. There are two regions I and II. We assume that P_I is the pressure in the region I, while P_{II} is the pressure in the region II. The direction of the pressure P_{I} is antiparallel to that of P_{I} . When the volume of regions I increases by ΔV . The work done is

$$\Delta W = P_I \Delta V - P_2 \Delta V$$

which is equal to the surface energy given by

$$\Delta K = \gamma \Delta A .$$

γ is in the unit of (erg/cm^2 or J/m^2). Here we use the work-energy theorem;

$$\Delta K = \Delta W$$

or

$$(P_I - P_{II})\Delta V = \gamma \Delta A$$

We define the pressure

$$P = P_I - P_{II}$$

which can be obtained as

$$P = \gamma \frac{\Delta A}{\Delta V}$$

For the case of sphere,

$$\Delta A = \Delta(4\pi r^2) = 8\pi r \Delta r , \qquad \Delta V = \Delta(\frac{4}{3}\pi r^3) = 4\pi r^2 \Delta r$$

Then we have

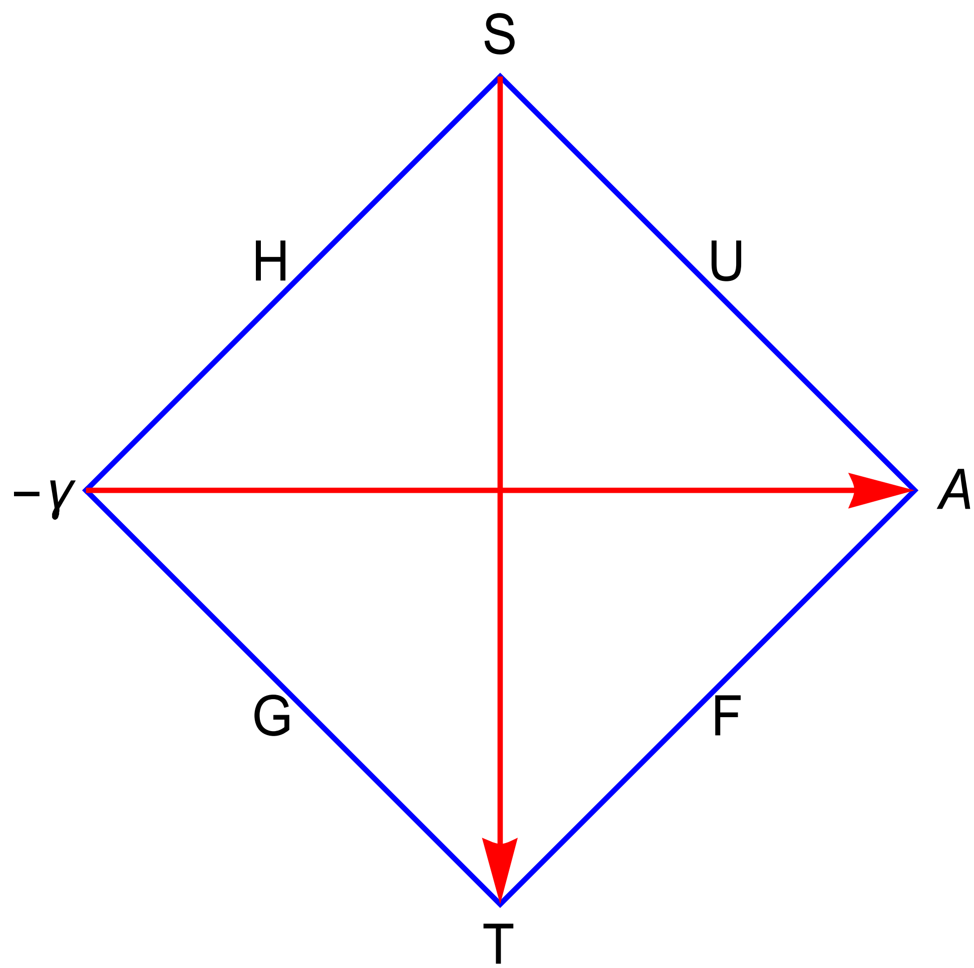
$$P = \gamma \frac{8\pi r \Delta r}{4\pi r^2 \Delta r} = \frac{2\gamma}{r}$$

2. Thermodynamic property

$$dU = TdS + \gamma dA$$

The correspondence relation;

$V \rightarrow A$, $\qquad P \rightarrow -\gamma$



Using the Maxwell's relation:

$$\left(\frac{\partial S}{\partial A}\right)_T = -\left(\frac{\partial \gamma}{\partial T}\right)_A$$

we have the relation

$$\left(\frac{\partial U}{\partial A}\right)_T = T\left(\frac{\partial S}{\partial A}\right)_T + \gamma = \gamma - T\left(\frac{\partial \gamma}{\partial T}\right)_A$$

REFERENCES

C.J. Adkins, An Introduction to Thermal Physics (Cambridge, 1987).