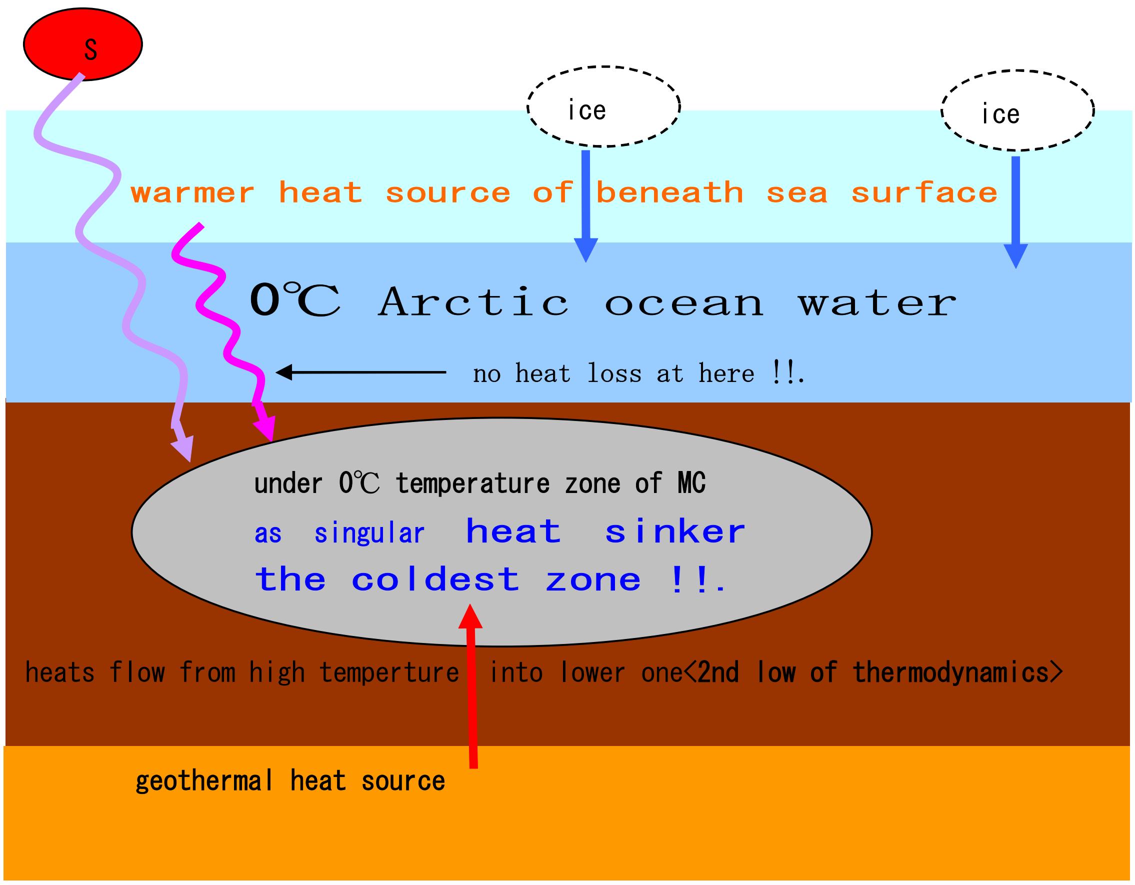
'08/12/14,

—Possibilities of abrupt temperature rise at Methan C reserver in Arctic—

Especially in arctic ocean, above all, MC is the stronger heat sinker just like as ice!!!!!. At there, **0 ℃** ocean water does not need heat. Many has been considering ocean is so hudge heat capacity, so the temperature rise would be also extremely slow pace, although actual temperature rise is dangerous exponential one, which is simuletaneously to drive also ocean in similar way.

[1]:Singular heat sink the M clathrate in the zero tmepetature sea flor:
<<the tunneling heat transfer by 0℃ ocean water>>:



Most of people consider that dangerous **methane clathrate**(MC) lie in sea flor, so heating it to melet, first of all, ocean must be warmed. Then ocean heat capacity is too hudge degree, that there need long time to melt MC. On the contrary, <u>in Arctic, heating up **0℃ ocean** with ice is not necessary</u>, most of heats at there are entirely flow into the most lower temperature zone of MC at rather short depth sea flor. <u>MC becomse colder as its position becomes more shallow</u>.

[2]:From microscopic diffusion to qusi-microscopic turbulence in oceans:

(1)Microscopic random collision of melecule realize **diffusion**. The essense is **gradient flow** toward realizing uniform density as **maximum value of entropy**.

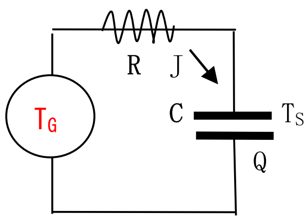
$\partial_t N(t,x) = -D\,\mathrm{div}V = D\,\mathrm{div}(\mathrm{grad}.N) = D\partial^2_k N(t,x)$. <D:diffusion coefficient>

$$\partial_t N(t,x) = D\partial^2_x N(t,x). \rightarrow N(t,x) = N_0\exp[-x^2/4Dt]/\sqrt{[4\pi Dt]}. \rightarrow \langle x^2\rangle = 2Dt.$$

$D = k_BT/m\eta$; $m\eta$ = **viscosity force** ; k_BT = **partitioning thermal(kinetic) energy**:

(2)Water fluid is fairly drived by **eddy current** which is irreversible due to enoumous molecule collisions. Therefore it seems quasi-diffusion of larger D. Ocean **water turbulence** by wind, hurricane or typhoon may be more lager D. After all, any kind of random phenomena of Brownian motion or eddy turbulence, they are all **random process** without regard to their spatial size. They may be unified by diffusion equation with various scale of diffusion coefficients.

[2]:time simulation on heat flow into heat capacity C by circuit equation :



J(t):**heat flow** into ocean. $Q(t) = \int_0^t dt J(t)$:**heat stock**,

$C = Q(t)/T_S(t)$:**heat capacity**.

$J(t) = (T_G(t) - T_S(t))/R$: gradient flow.

$Q'(t) = CT'_S(t) = J(t) = \langle T_G(t) - T_S(t)\rangle/R$.

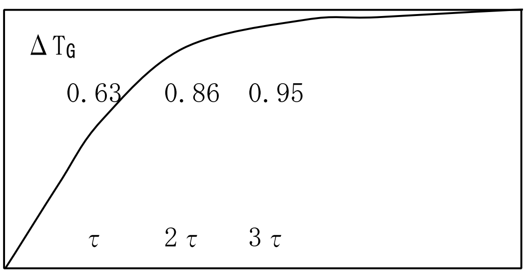
$T_S' + T_S/\tau = T_G/\tau$. $\langle CR \equiv \tau\rangle$

$$T_S(t) = T_S(0)\exp[-t/\tau] + \tau^{-1}\int_0^t du\, T_G(u)\exp[-(t-u)/\tau].$$

(1)driving by step function temperature rise : $T_G(u) \equiv \Delta T_G$

$T_S(t) = \tau^{-1}\int_0^t du\,\Delta T_G \exp[-(t-u)/\tau] = \Delta T_G\tau^{-1}\exp[-t/\tau]\int_0^t du \exp[u/\tau]$.

$= \Delta T_G \exp[-t/\tau][\exp(t/\tau) - 1] = \Delta T_G[1 - \exp(-t/\tau)]$.



$J(t) = CT'_S(t) = C\Delta T_G/\tau[\exp(-t/\tau)]$.

$= (\Delta T_G/R)[\exp(-t/\tau)]$.

As is seen, time lag is called τ.

(2)driving by exponential increasing temperature : $T_G(t)\equiv T_G[\exp[t/\tau*]-1]$

$$T_S(t)=\tau^{-1}\int_0^t du\, T_G[\exp[u/\tau*]-1]\exp[-(t-u)/\tau]$$

$$=-\tau^{-1}T_G\int_0^t du \exp[-(t-u)/\tau]+\tau^{-1}\int_0^t du\, T_G[\exp[u/\tau*]\exp[-(t-u)/\tau]$$

$$=-T_G[1-\exp(-t/\tau)]+(1/\tau*+1/\tau)^{-1}\tau^{-1}T_G\exp(-t/\tau)[\exp\langle t(1/\tau*+1/\tau)\rangle-1]$$

$\tau*\equiv\tau/k.$

$$=-T_G[1-\exp(-t/\tau)]+(1/\tau*+1/\tau)^{-1}\tau^{-1}T_G\exp(-t/\tau)[\exp\langle t(1+k)/\tau)\rangle-1]$$

$$=-T_G[1-\exp(-t/\tau)]-(1+k)^{-1}T_G\exp(-t/\tau)+(1+k)^{-1}T_G\exp\langle kt/\tau)\rangle$$

$$=-T_G+T_G\exp(-t/\tau)[1-(1+k)^{-1}]+(1+k)^{-1}T_G\exp\langle kt/\tau)\rangle$$

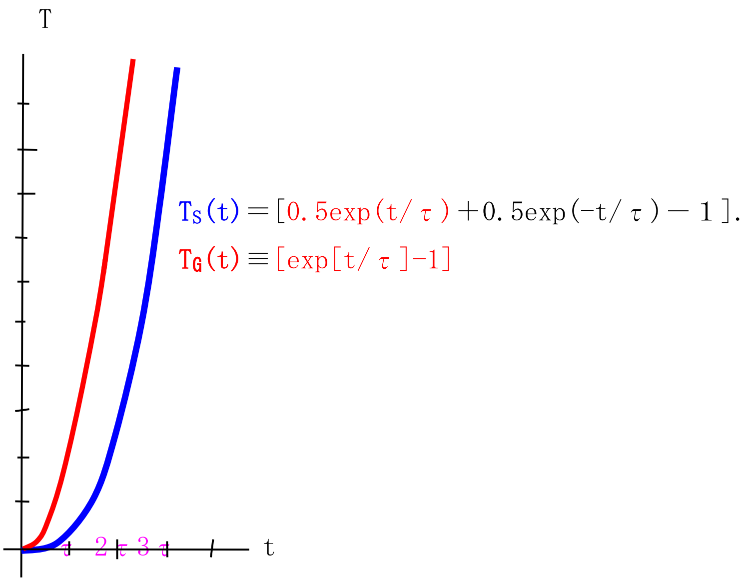
$$T_S(t)=T_G[(1/(1+k))\exp(kt/\tau)+(k/(1+k))\exp(-t/\tau)-1].$$

(3)in case of k=1:

$$T_S(t)=T_G[0.5\exp(t/\tau)+0.5\exp(-t/\tau)-1].$$

t=0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	
T_S=0	0.13	0.54	1.35	2.76	5.1	9.6	15.6	26.3	

t=0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	
T_G=0	0.65	1.7	3.38	6.34	11.18	19.1			



Now global temperature rise is exponetial growing indicating its instability.

As is seen, **exponential driving** make both similar steepest curvature with the phase shift(time lag) almost $0.5\tau\sim\tau$. Note certainly there exists some time lag, though ocean temperature rise is not anymore slow.

[3]:time simulation on 1 dim heat flow in distributed elements of {R,C} :

(1)**time solution as normal distribution with expanding deviation:**

$T(x;t) \equiv T_0 \exp[-x^2/4Dt]/\sqrt{[4\pi Dt]}$.   <deviation: $\sigma = \sqrt{[2Dt]}$.>

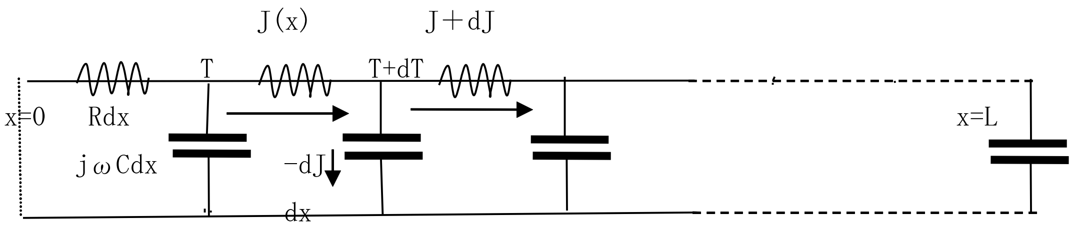
$\langle x^2 \rangle = 2Dt$. → (2/2) σ depth $= \sqrt{[2Dt]} \equiv L_2$. <95% reaching length of heat flow>

T(x;t) is temperature distribution(respons) by Delta function input at t=x=0.

It may be primitive heat transfer model by taking appropriate diffusion const D.

(2)1 dimensional heat diffusion simulator as distributed RC circuit.

Note that following distributed circuit is equivalent to single RC one of [2] .



☞ : $j\omega = d/dt$.

$-dT = J\,Rdx$. → $-dT/dx = RJ$. →

$-dJ = j\omega\, dxCT$. → $-dJ/dx = j\omega CT$. →

—1dim diffusion equation—

(a)$d^2T/dx^2 = j\omega CRT = CR(dT/dt)$.

(b)$d^2J/dx^2 = j\omega CRJ = CR(dJ/dt)$.

(c)$D = 1/CR$. pseudo diffusion coefficient.

(d)$C = C_0/L$.   <L=concerned ocean depth, C_0=the ocean heat total capacity>

(e)$D = \langle x^2 \rangle/2t$. → $x = \sqrt{[2Dt]}$. → $v = dx/dt = (1/2)\sqrt{[2D/t]}$.

(f)$L = \sqrt{[2Dt_L]}$. → $t_L = L^2/2D$: time of 95% reaching at depth L.

(g)$T(L;t_L) \equiv T_0 \exp[-1/2]/\sqrt{[2\pi L^2]}$. ← almost zero temperature at deep sea flor.

(h)Where 0℃ zone(co-being ice and water) without temperature gradient zero does not need heat absorbtion. Then heat flow would be tunneling at there <singluar point at phase transition>.

See again the discussion at [1].

Reference:

新楽,田辺,権平編, 共立物理学公式,共立出版,1970,Tokyo.

☞:This report was written in haste without carefull surveylance, so mistakes shall be corrected in the later.