From: **Michael Carbajales-Dale** madale@clemson.edu
Subject: Re: Thoughts on Eq. 5.51
Date: January 24, 2015 at 4:43 PM
To: Matthew Heun mkh2@calvin.edu, Becky Haney brh22@calvin.edu

DM

Heya,

I'd like to try two things (not for the book!)

1. Work backwards assuming that dB_0/dt = \sum_j B_j0

2. Work this through in terms of embodied energy = exergy destruction within economic processes.

Mik

On 1/23/15 8:52 AM, Matthew Heun wrote:

> Mik and Becky:
>
> Here are some thoughts on the question Mik raised yesterday about Eq. 5.51. For discussion shortly.
>
> Cheers,
>
> Matt
>
> New book: Beyond GDP: National Accounting in the Age of Resource Depletion
>
> Springer: http://www.springer.com/energy/policy%2C+economics%2C+management+%26+transport/book/978-3-319-12819-1
> Amazon: http://www.amazon.com/Beyond-GDP-National-Accounting-Depletion/dp/3319128191/ref=sr_1_1?ie=UTF8&qid=1420398244

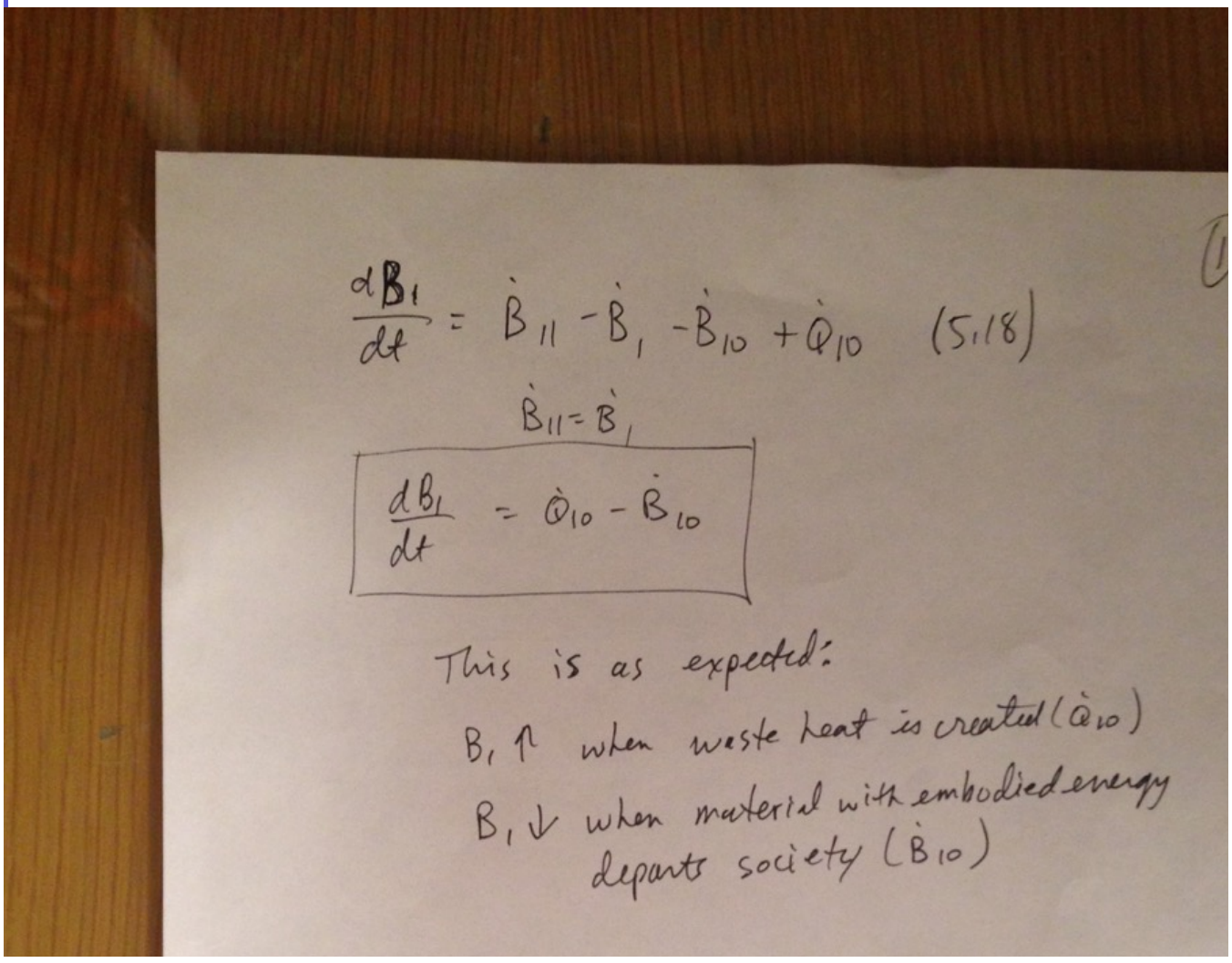

Fig. 4.3. 1-sector economy

$$\frac{dE_0}{dt} = \dot{Q}_{10} - \dot{E}_{01} \quad (4.4)$$

$$\frac{dE_1}{dt} = \dot{E}_{01} + \dot{E}_{11} - \dot{E}_1 - \dot{Q}_{10} \quad (4.5)$$

Add both eqns (4.4)+(4.5)

$$\frac{dE_0}{dt} + \frac{dE_1}{dt} = \dot{Q}_{10} - \dot{E}_{01} + \dot{E}_{01} - \dot{Q}_{10}$$

$$\frac{dE_0}{dt} + \frac{dE_1}{dt} = 0$$

Rate of change of ~~total~~ direct energy in the whole system is zero.

$\therefore E_0 + E_1 =$ constant

why? Biosphere (0) + [illegible]

Side note if we assume $\frac{dE_1}{dt} = 0 \Rightarrow \frac{dE_0}{dt} = 0$

$\frac{dE_0}{dt} = \dot{Q}_{10} - \dot{E}_{01} = 0 \Rightarrow$ Extraction from biosphere ($\dot{E}_{01}$) balanced by waste heat returning to biosphere ($\dot{Q}_{10}$).

Fig 5.2 1-sector economy (3)

$\frac{dT_0}{dt} = \dot{T}_{10} - \dot{T}_{01}$ (5.9)

$\frac{dT_1}{dt} = \dot{T}_{01} + \dot{T}_{11} - \dot{T}_1 - \dot{T}_{10}$ (5.10)

Add both eqns (5.9) + (5.10)

$\frac{dT_0}{dt} + \frac{dT_1}{dt} = \dot{T}_{10} - \dot{T}_{01} + \dot{T}_{01} - \dot{T}_{10}$

$\frac{dT_0}{dt} + \frac{dT_1}{dt} = 0$

Expand terms

$$\frac{dE_0}{dt} + \frac{dB_0}{dt} + \frac{dE_1}{dt} + \frac{dB_1}{dt} = 0$$

Substitute 1st law $\left(\frac{dE_0}{dt} + \frac{dE_1}{dt} = 0 \right)$

$$\boxed{\frac{dB_0}{dt} + \frac{dB_1}{dt} = 0}$$

Similar to (5.51)

Start with $\frac{dB_0}{dt} + \frac{dB_1}{dt} = 0$. Subin $\frac{dB_1}{dt} = \dot{Q}_{10} - \dot{B}_{10}$ (4)

$$\frac{dB_0}{dt} + \dot{Q}_{10} - \dot{B}_{10} = 0$$

$$\frac{dB_0}{dt} = \dot{B}_{10} - \dot{Q}_{10}$$

Subin 1st law $\frac{dE_1}{dt} = \dot{E}_{10} + \dot{E}_{20} - \dot{E}_{30} - \dot{Q}_{10}$ (4.5) 90°

$\dot{Q}_{10} = \dot{E}_{01}$

$\frac{dB_0}{dt} = \dot{B}_{10} - \dot{E}_{01}$ [same as (5.13)

which was derived on p. 94, 96 assuming $\dot{B}_{01} = 0$ and $\dot{T}_0 = \dot{E}_{01}$ and $\frac{dE_0}{dt} = \frac{dE_1}{dt} = 0$.]

I think this all hangs together.

Maybe the last thing would be to delete lines 284–290 in Ch. 5.

~~Bottom line Eq. (5.51) is a consequence of $\frac{dE_1}{dt} = 0$~~