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Erratum: General equilibrium second-order hydrodynamic coefficients for free quantum fields

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In section 3, as the partition function is included in the definition of the statistical operator $\hat{\rho}$, eq. (3.1) should read:

$$\langle \hat{O}(x) \rangle = \text{tr} \left(\hat{\rho} \hat{O}(x) \right)_{\text{ren}}.$$

The correct expression of the eq. (5.6) is:

$$\begin{aligned} D_w &= \frac{1}{2} \left(C^{01|01|11|22} - C^{01|02|11|21} - C^{02|01|11|12} + C^{02|02|11|11} \right) \\ &\quad - \frac{1}{3} \left(C^{02|03|12|31} - C^{03|03|12|21} - C^{02|01|12|33} + C^{03|01|12|23} \right), \\ A &= C^{00|00|12|12}, \quad W = C^{02|03|12|31} - C^{03|03|12|21} - C^{02|01|12|33} + C^{03|01|12|23}, \\ G &= \frac{1}{2} \left(C^{00|03|03|11} - C^{00|01|03|13} + C^{03|00|03|11} - C^{01|00|03|31} \right). \end{aligned}$$

	$m=0, \mu=0$	a_n	$f(x) \quad x=m/T \gg 1$
A	$\frac{(1-6\xi)}{6}T^4$	$\frac{1}{4}[(4\xi-2)x^{-2}K_2(nx) + (1-4\xi)x^{-1}nK_3(nx)]$	$\frac{1}{4}(1-4\xi + (19-108\xi)/8x)$
G	$\frac{(1+6\xi)}{18}T^4$	$\frac{1}{6}[(6\xi-3)x^{-2}K_2(nx) + nx^{-1}K_3(nx)]$	$\frac{1}{6}(1+6(\xi+11/8)/x)$

Table 1. The stress-energy tensor coefficients (5.3) for a free Boson field: the first column reports the coefficients in the massless case with $\mu=0$, the second column reports the n th term of the expansion (8.2), the third column reports the asymptotic expansion at low temperature (8.3). Our result for W in the massless case agrees with that obtained in ref. [29] for λ_3 (see eq. (9.1)).

The proper coefficients for Boson field in eq. (5.23) are

$$\begin{aligned}
 W &= \frac{(2\xi-1)}{12\pi^2\beta^2} \int_0^\infty \frac{dp}{E_p} (n_B''(E_p-\mu) + n_B''(E_p+\mu)) p^4, \\
 A &= \frac{1}{24\pi^2\beta^2} \int_0^\infty \frac{dp}{E_p} (n_B''(E_p-\mu) + n_B''(E_p+\mu)) (2p^4(1-6\xi) + p^2m^2(3-12\xi)), \\
 G &= \frac{1}{36\pi^2\beta^2} \int_0^\infty \frac{dp}{E_p} (n_B''(E_p-\mu) + n_B''(E_p+\mu)) (p^4(1+6\xi) + 3p^2m^2), \\
 D_\alpha &= \frac{1}{144\pi^2\beta^2} \int_0^\infty \frac{dp}{E_p} (n_B''(E_p-\mu) + n_B''(E_p+\mu)) (8p^4(6\xi-1) + 3p^2m^2(24\xi-5));
 \end{aligned}$$

likewise we correct some typos in table 1. The faithful exponent of i in eq. (5.26) is as follows:

$$\mathcal{D}_{\mu\nu}(\partial_{X_1}, \partial_{X_2}) = \frac{i^{\delta_{0\mu}+\delta_{0\nu}}}{4} [\tilde{\gamma}_\mu(\partial_{X_2} - \partial_{X_1})_\nu + \tilde{\gamma}_\nu(\partial_{X_2} - \partial_{X_1})_\mu].$$

Similarly, in eq. (5.30) the exponent of p needs to be corrected:

$$G = \frac{1}{72\pi^2\beta^2} \int_0^\infty \frac{dp}{E_p} (n_F''(E_p-\mu) + n_F''(E_p+\mu)) (4p^4 + 3m^2p^2).$$

In eq. (6.3) N_α and N_w a factor 3 was omitted, the correct equations read:

$$\begin{aligned}
 N_\alpha &= \frac{1}{2|\beta|^2} \int_0^{|\beta|} d\tau_1 d\tau_2 \langle T_\tau \left(\hat{K}_{-i\tau_1}^3 \hat{K}_{-i\tau_2}^3 \hat{j}^0(0) \right) \rangle_{T,c}, \\
 N_w &= \frac{1}{2|\beta|^2} \int_0^{|\beta|} d\tau_1 d\tau_2 \langle T_\tau \left(\hat{\mathcal{J}}_{-i\tau_1}^3 \hat{\mathcal{J}}_{-i\tau_2}^3 \hat{j}^0(0) \right) \rangle_{T,c}.
 \end{aligned}$$

Same in eq. (6.5), which should read:

$$\begin{aligned}
 N_\alpha &= \frac{1}{2} C^{00|00|0|33}, \\
 N_w &= \frac{1}{2} \left(C^{01|01|0|22} - C^{01|02|0|21} - C^{02|01|0|12} + C^{02|02|0|11} \right), \\
 G^V &= -\frac{1}{2} \left(C^{00|03|3|11} - C^{00|01|3|13} + C^{03|00|3|11} - C^{01|00|3|31} \right).
 \end{aligned}$$

Some terms within round brackets in the two unnumbered equations after eq. (7.4) were not correctly written. The correct equations read:

$$\begin{aligned}\partial_\mu j_A^\mu &= \partial_\mu (w^\mu W^A) = -\alpha \cdot w \left(3 \frac{W^A}{|\beta|} + \frac{\partial}{\partial |\beta|} W^A \right) \\ \left(3 \frac{W^A}{|\beta|} + \frac{\partial}{\partial |\beta|} W^A \right) &= \frac{m^2}{2\pi^2 \beta^2} \int_0^\infty dp \left(n'_F(E_p - \mu) + n'_F(E_p + \mu) \right).\end{aligned}$$

Finally, we have found that N_α coefficient for Boson field in eq. (6.9) was not correctly calculated. The precise expression reads:

$$N_\alpha = \frac{m^2}{48\pi^2 \beta^2} \int_0^\infty dp \left(n''_B(E_p - \mu) - n''_B(E_p + \mu) \right);$$

correspondingly the corrected table 3 is reported herein.

	$m = 0 \quad \mu = 0$	b_n	$g(x) \quad x = m/T \gg 1$
N_α^V	0	$\frac{1}{24} [n^2 K_3(nx) - 4x^{-1} n K_2(nx)]$	$\frac{x}{64} (1 - 20/x + 8x/3)$
G^V	0	$-\frac{1}{6} x^{-1} n K_3(nx)$	$-\frac{1}{6} (1 + 15/8x)$

Table 3. The vector current coefficients (6.3) for an ideal boson field: the first column is the result at $m = 0$ and $\mu = 0$, the second column is the generic terms of the series expansion (8.4), the third column is the asymptotic expansion for low temperature (8.5).

Same in eq. (6.11) for Dirac field; correct expressions for N_w and G_V are:

$$\begin{aligned}N_w &= -\frac{1}{8\pi^2 \beta^2} \int_0^\infty \frac{dp}{E_p} \left(n'_F(E_p - \mu) - n'_F(E_p + \mu) \right) (2p^2 + m^2), \\ G^V &= -\frac{1}{12\pi^2 \beta^2} \int_0^\infty \frac{dp}{E_p} \left(n'_F(E_p - \mu) - n'_F(E_p + \mu) \right) (2p^2 + m^2),\end{aligned}$$

and the corresponding updated tables 4 and 5 with the corrected values are quoted below.

	$m = 0$	b_n	$g(x) \quad (m/T \gg 1)$
N_w^V	$\frac{T^2 \mu}{4\pi^2}$	$-\frac{1}{8} [2nx^{-2} K_0(nx) + x^{-1} K_1(nx)]$	$\frac{1}{8} (1 + 15/8x)$
G^V	$\frac{T^2 \mu}{6\pi^2}$	$\frac{1}{12} [2nx^{-2} K_0(nx) + x^{-1} K_1(nx)]$	$\frac{1}{12} (1 + 15/8x)$

Table 4. The vector current coefficients (6.3) for an ideal Dirac field: the first column is the result at $m = 0$, the second column is the generic terms of the series expansion (8.4), the third column is the asymptotic expansion for low temperature (8.5).

...	...
$\beta^2 N_w^V$	$\frac{\mu}{8\pi^2} \frac{2b^2 - 1}{b\sqrt{b^2 - 1}}$
$\beta^2 G^V$	$\frac{\mu}{12\pi^2} \frac{2b^2 - 1}{b\sqrt{b^2 - 1}}$
...	...

Table 5. The coefficients of the energy momentum tensor (5.3), the vector current (6.3) and axial current (7.1) for the Dirac field at $T = 0$ and finite chemical potential μ , where $b = \mu/m$.

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