Scaling dimensions of monopole operators in the CPNb!1 theory in 2 + 1 dimensions

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<td>Published Version</td>
<td>doi:10.1007/JHEP06(2015)037</td>
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Erratum: Scaling dimensions of monopole operators in the $\mathbb{CP}^{N_b-1}$ theory in $2 + 1$ dimensions

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Erratum to: JHEP06(2015)037

ArXiv ePrint: 1504.00368

A missing factor of $i$ was found in the computation of the mixed kernel $F^{q,B}_j(\omega)$. This results in minor changes in our formulas, but a major change in our conclusions. First, we correct the formulas, then we present the corrected conclusions.

Corrected formulas. The correct expression replacing (4.47) in the original article is

$$F^{q,B}_j(\omega) = \frac{16q\pi^2 i}{(2j + 1)\sqrt{j(j + 1)}} \sum_{j',j''=q}^\infty \frac{E_{qj'} + E_{qj''}}{2E_{qj'}E_{qj''}(\omega^2 + (E_{qj'} + E_{qj''})^2)} I_H(j,j',j'').$$

(1)

Because $F^{q,B}_j(\omega)$ is pure imaginary the matrix of coefficients $M^q_j(\omega)$ is not Hermitian, and (4.12) is modified to

$$M^q_j(\omega) = \begin{pmatrix} D^q_j(\omega) & F^{q,B}_j(\omega) & F^{q,\tau}_j(\omega) & F^{q,E}_j(\omega) \\ -F^{q,B*}_j(\omega) & K^{q,BB}_j(\omega) & K^{q,\tau B}_j(\omega) & K^{q,EB}_j(\omega) \\ -F^{q,\tau*}_j(\omega) & K^{q,\tau B*}_j(\omega) & K^{q,\tau E}_j(\omega) & K^{q,E*}_j(\omega) \\ -F^{q,E*}_j(\omega) & K^{q,EB*}_j(\omega) & K^{q,\tau E*}_j(\omega) & K^{q,EE}_j(\omega) \end{pmatrix}.$$  

(2)
Consequently, the eigenvalues of the matrix are changed, (4.16) and (4.19) are changed to
This matrix has eigenvalues:
\[
\lambda_q^\pm = \frac{D_q^j(\omega) + K_j^{q,BB}(\omega) \pm \sqrt{(D_q^j(\omega) - K_j^{q,BB}(\omega))^2 - 4|F_j^{q,B}(\omega)|^2}}{2},
\]
\[
\lambda_q^E = \frac{j(j+1)+\omega^2}{j(j+1)}K_j^{q,\tau\tau},
\]
and
\[
\delta F_q = \frac{1}{2} \int \frac{d\omega}{2\pi} \log \frac{D_q^j(\omega)}{D_0^j(\omega)} + \sum_{j=1}^{\infty} (2j+1) \log \left( \frac{K_j^{q,\tau\tau}(\omega)}{D_q^j(\omega)} \right) \left( F_j^{q,B}(\omega) \right)^2
\]
respectively.

All formulas in the appendices are fixed by inserting an \( i \) in the appropriate places.
The only nontrivial replacement is in (C.49), which correctly reads
\[
L_q^j(\omega) = \frac{8\mu_q^2}{(j + \frac{1}{2})^2 + \omega^2} + \frac{12F_q^\infty}{\pi} \left( j + \frac{1}{2} \right)^2 - \omega^2
- \frac{(q^2 + 4\mu_q^2(q^2 - 1))(j + \frac{1}{2})^2 + 4(-q^2 + \mu_q^2(8q^2 - 5))\omega^2}{2 \left( (j + \frac{1}{2})^2 + \omega^2 \right)^3}
+ 144B_q \frac{3(j + \frac{1}{2})^4 - 24(j + \frac{1}{2})^2\omega^2 + 8\omega^4}{(j + \frac{1}{2})^2 + \omega^2} + \frac{3F_q^\infty}{2\pi} \left( 25 - 48\mu_q^2 \right)(j + \frac{1}{2})^4
+ 3(64\mu_q^2 - 55)(j + \frac{1}{2})^2\omega^2 + 20\omega^4
+ O \left( \frac{1}{(j + \frac{1}{2})^2 + \omega^2} \right)^3.
\]

This change has important consequences on our final results. All monopoles are stable, invalidating section 5.1. The large \( q \) analysis supports the stability of monopoles; (5.9), (5.10) and figure 4 are replaced by
\[
M_q^j(0) = \zeta \left( \frac{3}{2}, \frac{1}{2} + \chi_0 \right) \frac{1}{8\pi \sqrt{2q}} \begin{pmatrix}
\frac{1}{2} & i\sqrt{j(j+1)} \chi_0 & 0 & 0 \\
0 & 2j(j+1) \chi_1 & 0 & 0 \\
0 & 0 & 4j(j+1)(\chi_0^2 + \chi_1) & 0 \\
0 & 0 & 0 & 0
\end{pmatrix},
\]
\[
\lambda_\pm^q \approx \frac{-0.055251 \pm 0.023717i}{\sqrt{q}}, \quad \lambda_E^q \approx \frac{0.063044}{\sqrt{q}}
\]
and figure 1.
Figure 1. The numerical results for the three eigenvalues, $\lambda_E^q$, $\lambda_+^q$, and $\lambda_-^q$ are plotted against the analytic large $q$ value in black.

Table 1. Results of the large $N_b$ expansion of the monopole operator dimensions $\Delta_q$ obtained through calculating the ground state energy in the presence of $2q$ units of magnetic flux through $S^2$. In the last column of the table we listed our estimates for when the monopole operators are relevant.

<table>
<thead>
<tr>
<th>$q$</th>
<th>$\Delta_q$</th>
<th>$N_b$ for which $\Delta_q &lt; 3$</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>$&lt; \infty$</td>
</tr>
<tr>
<td>1/2</td>
<td>$0.1245922 N_b + 0.3815 + O(N_b^{-1})$</td>
<td>$\leq 21$</td>
</tr>
<tr>
<td>1</td>
<td>$0.3110952 N_b + 0.8745 + O(N_b^{-1})$</td>
<td>$\leq 6$</td>
</tr>
<tr>
<td>3/2</td>
<td>$0.5440693 N_b + 1.4646 + O(N_b^{-1})$</td>
<td>$\leq 2$</td>
</tr>
<tr>
<td>2</td>
<td>$0.8157878 N_b + 2.1388 + O(N_b^{-1})$</td>
<td>none</td>
</tr>
<tr>
<td>5/2</td>
<td>$1.1214167 N_b + 2.8879 + O(N_b^{-1})$</td>
<td>none</td>
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Results and conclusions. Because these corrections make all saddle points stable, we are able to compute the dimensions of monopole for many values of $q$. The results are listed in table 1. In particular our result for $\Delta_{1/2}$ is different, and compares favorably with the numbers obtained by quantum Monte Carlo simulations of refs. [1–3] even for small $N_b$, as shown in the replacement of figure 1 of the original article in figure 2. From comparing the scaling dimensions collected in table 1 to 3, we can also estimate the upper bound on $N_b$ below which the monopole operators are expected to be relevant; these bounds are also presented in table 1. There is inherently some uncertainty in these estimates, as they come from extrapolating the large $N_b$ expansion to small values of $N_b$. Nevertheless, our relevance bounds come close to what ref. [3] found from numerics, as can be seen from table I in [3].

Acknowledgments

We are grateful to Nathan Agmon, whose joint work with SSP found the factor of $i$ discussed in this Erratum in the original version of this paper.
Figure 2. The scaling dimension of the $q = 1/2$ monopole operator, $\mathcal{F}_{1/2}$. The full line is the $N_b = \infty$ result (ref. [4]), and the dashed line is the leading $1/N_b$ correction computed in the present paper (see table 1). The quantum Monte Carlo results are for lattice antiferromagnets with global SU($N_b$) symmetry on the square (refs. [1, 2]), honeycomb (ref. [3]), and rectangular (ref. [3]) lattices.

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References


