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Erratum: Scaling dimensions of monopole operators in the $\mathbb{C}P^{N_b-1}$ theory in $2 + 1$ dimensions

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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

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

$$M^{q}_{j}(\omega) = \begin{pmatrix}
    D^{q}_{j}(\omega) & F^{q,B}_{j}(\omega) & F^{q,\tau}_{j}(\omega) & F^{q,E}_{j}(\omega) \\
    -F^{q,B\ast}_{j}(\omega) & K^{q,BB\ast}_{j}(\omega) & K^{q,\tau B\ast}_{j}(\omega) & K^{q,EB\ast}_{j}(\omega) \\
    -F^{q,\tau\ast}_{j}(\omega) & K^{q,\tau B\ast}_{j}(\omega) & K^{q,\tau\tau\ast}_{j}(\omega) & K^{q,\tau E\ast}_{j}(\omega) \\
    -F^{q,E\ast}_{j}(\omega) & K^{q,EB\ast}_{j}(\omega) & K^{q,\tau E\ast}_{j}(\omega) & K^{q,EE\ast}_{j}(\omega)
\end{pmatrix}. $$ (2)
Consequently, the eigenvalues of the matrix are changed, (4.16) and (4.19) are changed to
\[
\lambda_\pm = \frac{(D_j^q(\omega) + K_j^{q,BB}(\omega)) \pm \sqrt{(D_j^q(\omega) - K_j^{q,BB}(\omega))^2 - 4|F_j^{q,B}(\omega)|^2}}{2},
\]
(3)
and
\[
\lambda_E^q = \frac{j(j + 1) + \omega^2}{j(j + 1)} K_j^{q,\tau\tau},
\]
and
\[
\delta F_q = \frac{1}{2} \int \frac{d\omega}{2\pi} \left[ \log \frac{D_j^q(\omega)}{D_0^q(\omega)} + \sum_{j=1}^{\infty} (2j+1) \log \frac{K_j^{q,\tau\tau}(\omega) \left[ D_j^q(\omega) K_j^{q,BB}(\omega) + |F_j^{q,B}(\omega)|^2 \right]}{D_0^q(\omega) K_0^{q,\tau\tau}(\omega) K_0^{q,BB}(\omega)} \right]
\]
(4)
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
\[
L_j^q(\omega) = \frac{8\mu_q^2}{(j + \frac{1}{2})^2 + \omega^2} + \frac{12\mathcal{E}_{q}}{\pi} \frac{(j + \frac{1}{2})^2 - \omega^2}{[(j + \frac{1}{2})^2 + \omega^2]^{5/2}}
- \frac{(q^2 + 4\mu_q^2(8\mu_q^2 - 1))(j + \frac{1}{2})^2 + 4(-q^2 + \mu_q^2(8\mu_q^2 - 5))\omega^2}{2[(j + \frac{1}{2})^2 + \omega^2]^3}
+ 144\mathcal{T}_q 3(j + \frac{1}{2})^4 - 24(j + \frac{1}{2})^2\omega^2 + 8\omega^4
+ \frac{3\mathcal{E}_{q}}{2\pi} \frac{(25 - 48\mu_q^2)(j + \frac{1}{2})^4 + 3(64\mu_q^2 - 55)(j + \frac{1}{2})^2\omega^2 + 20\omega^4}{[(j + \frac{1}{2})^2 + \omega^2]^{9/2}}
+ O \left( \frac{1}{[(j + \frac{1}{2})^2 + \omega^2]^3} \right).
\]
(5)
This change has important consequences on our final results. \textit{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
\[
M_j^q(0) = \frac{\zeta(\frac{3}{2}, \frac{1}{2} + \chi_0)}{8\pi^2 \sqrt{2q}} \begin{pmatrix}
\frac{1}{j+1} \\
\frac{1}{j} \\
0 \\
0 \\
0 \\
0 \\
0 \\
0
\end{pmatrix} \begin{pmatrix}
\chi_0 \\
\chi_0 \\
\chi_0 \\
\chi_0 \\
\chi_0 \\
\chi_0 \\
\chi_0 \\
\chi_0
\end{pmatrix} \begin{pmatrix}
\frac{1}{2} \\
i\sqrt{j(j + 1)} \chi_0 \\
2j(j + 1) \chi_1 \\
0 \\
0 \\
0 \\
0 \\
0
\end{pmatrix},
\]
(6)
\[
\lambda_\pm^q \approx - \frac{0.055251 \pm 0.023717i}{\sqrt{q}}, \quad \lambda_E^q \approx \frac{0.063044}{\sqrt{q}}.
\]
(7)
and figure 1.
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

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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


