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Thick-Center-Vortex-Model and the Coulomb Potential

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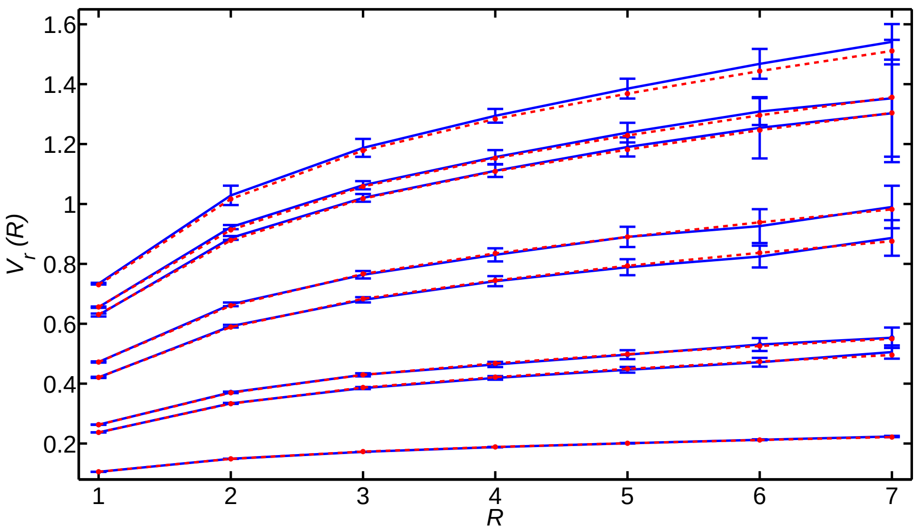
The potentials for various SU(3) representations are calculated by means of an analytical model for thick center vortices. We discuss the influence of fluctuations of non-quantized, closed magnetic flux lines of short range on the potential. We fit the model parameters to lattice data by G.S.Bali [1]. We will show that the Casimir scaling of this data can only be fitted, if the vortices are never fully contained in the Wilson loop in time-direction. Therefore, we conclude that Casimir scaling for large R is an effect due to the finite range of the Wilson loop in time-direction. If we include this effect in our model by a change of the vortex profile, we obtain the fit, which is illustrated in the following picture. G.S.Bali's data are connected with full lines and are shown with the modified error bars. In dashed lines, one can see the fitted data.



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1. Coulombic contributions

It was already shown [2, 3] that the approximate 'Casimir scaling' of the potentials $V_r(R)$ for higher representations $r = 3, 6, 8, 10, 15s, 15a, 24, 27$ can be achieved by means of thick center vortices. Now, we actually try to fit the parameters of this thick-center-vortex-model to lattice data [1]. The different potentials $V_r(R)$ are given by

$$V_r(R) = -\sum_x \ln\left\{1 - f\left[1 - G_r\left(\alpha_V(x)\right)\right] - f_c\left[1 - G_r\left(\alpha_c(x)\right)\right]\right\} + d_r \tag{1.1}$$

with $G_r(\alpha) = \frac{1}{\mathrm{dim_r}}\mathrm{Tr}\left(e^{i\vec{\alpha}\vec{H}}\right)$. α_V is the vortex profile function, which is given by the function $\alpha_v(x) = \frac{1}{2}\left[\tanh\left(a(x+R/2)\right) - \tanh\left(a(x-R/2)\right)\right]$, a corresponds to the inverse vortex thickness and f parametrizes the probability that a vortex occurs.

Furthermore, we add a Coulombic contribution to $V_r(R)$, which behaves according to the perimeter law fall-off. These Coulombic contributions are thin, correlated and short magnetic flux lines, which are not quantized with the center element but with some smaller flux α_c and occur with a possibility f_c. The length inbetween their correlated piercings is Gaussian distributed. d_r is the selfenergy contribution. These constants should behave according to Casimir scaling.

2. Casimir scaling as finite size effects of the Wilson loop

If we fit the parameters to [1] for $\beta = 6.2$ and for the R- values in the above picture, a becomes very small ($a = 0.0022$), which means that the vortices are very thick, in fact thicker than the string breaking radius at $R \approx 7$ would permit. We conclude that the Wilson loops in [1] are too short in time-direction in order to contain the full center vortex. In table VII of [1], one can see that the Wilson loops in time direction are smaller ($0.66r_0 \leq t_F(R) \leq 1.66r_0$ for the fundamental representation F) than the string breaking radius $R_{sb} = 2.4r_0$ given by G.S.Bali, with decreasing time-extent for larger R.

In order to take this effect into account, we increased our vortex profiles with increasing R by means of $\alpha_v^N = \frac{1}{2}\left[\tanh\left(\frac{a}{R^e}(x+R/2)\right) - \tanh\left(\frac{a}{R^e}(x-R/2)\right)\right]$. Additionally, we enlarged the error bars with the percentage p by which the Wilson loops in time direction are too small $p = \frac{R_{sb}}{t_r(R)}$. With these adaptions, we achieved a goodness-of-fit of 98% with the restriction that the selfenergies d_r deviate maximally from 5% to 15% from the Casimir scaling. The fit is displayed in the figure above. So, we conclude that the Casimir scaling for larger R and the absence of the string breaking effect in the figure is caused by the restricted time-extent of the Wilson loops.

References

[1] G. S. Bali, Phys. Rev. D **62** (2000) 114503 [arXiv:hep-lat/0006022].

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[3] S. Deldar, JHEP **0101** (2001) 013 [arXiv:hep-ph/9912428].