Super-Big J

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Critical $O(2)$ model in $D=3$ at large charge

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- We obtain an asymptotic expansion of the form

$$\Delta_J = c_{\frac{3}{2}} J^{+\frac{3}{2}} + c_{\frac{1}{2}} J^{+\frac{1}{2}} - 0.0108451 + O(J^{-\frac{1}{2}}) \ .$$

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  where $c_{\frac{3}{2}}$ and $c_{\frac{1}{2}}$ correspond to the two most relevant unknown Lagrangian coefficients.
- Locally, the $c_{\frac{3}{2}}$ coefficient corresponds to a leading-order equation of state of the form

$$\mathcal{H} \simeq (4\pi)^{+\frac{1}{2}} c_{\frac{3}{2}} \rho^{+\frac{3}{2}} \ .$$

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$$E \simeq \sqrt{\frac{4\pi}{\mathcal{A}}} c_{\frac{3}{2}} J^{\frac{+3}{2}}$$

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- Quantizing the effective theory gives a large-J expansion of the lowest operator dimension Δ_J with charge J in the $O(2)$ model,in terms of certain unknown coefficients in the effective Lagrangian for χ.
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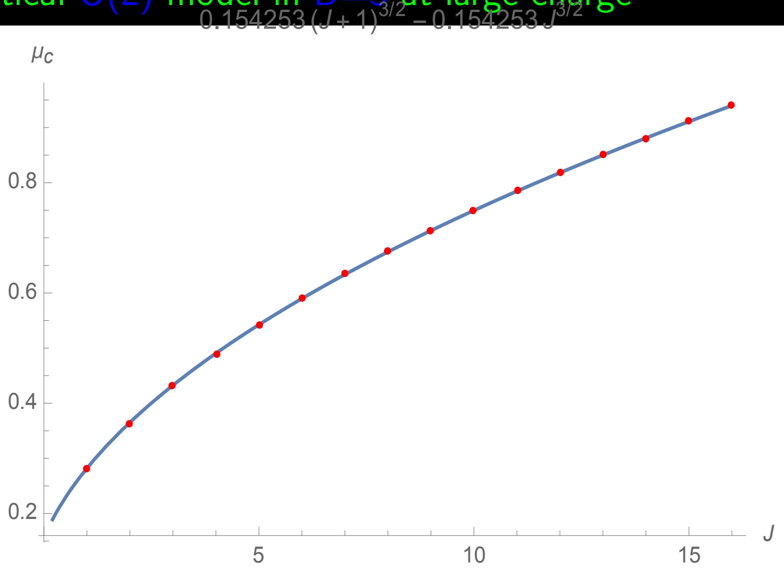

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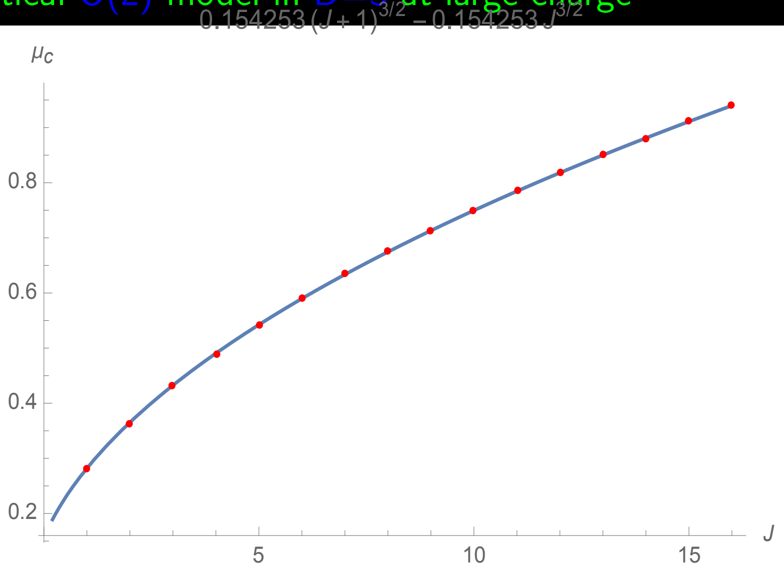

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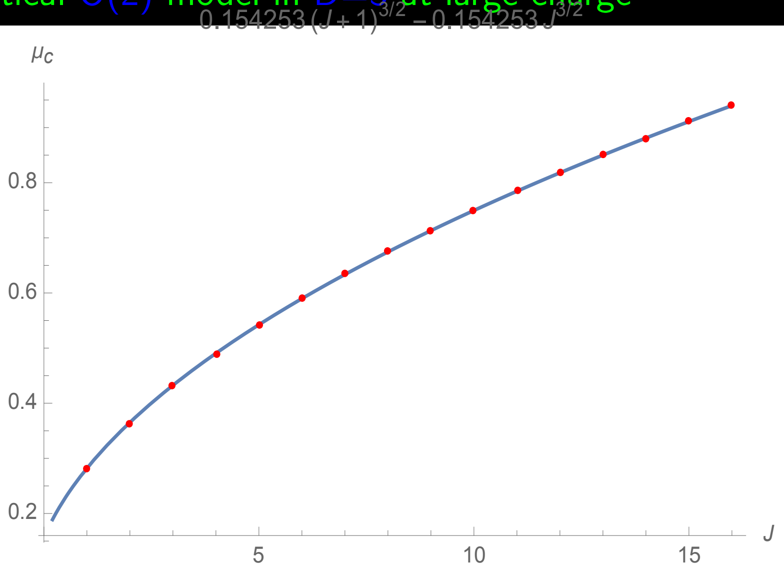

Here, we are plotting $\Delta_{J+1} - \Delta_J$

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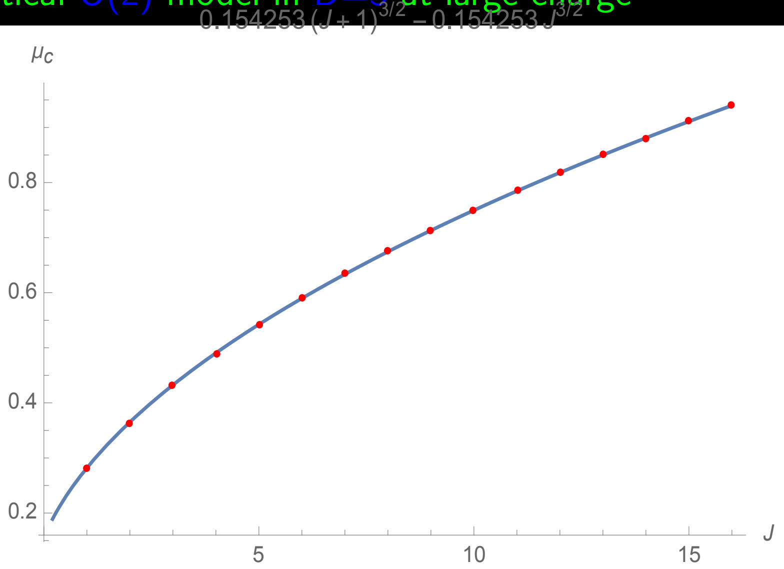
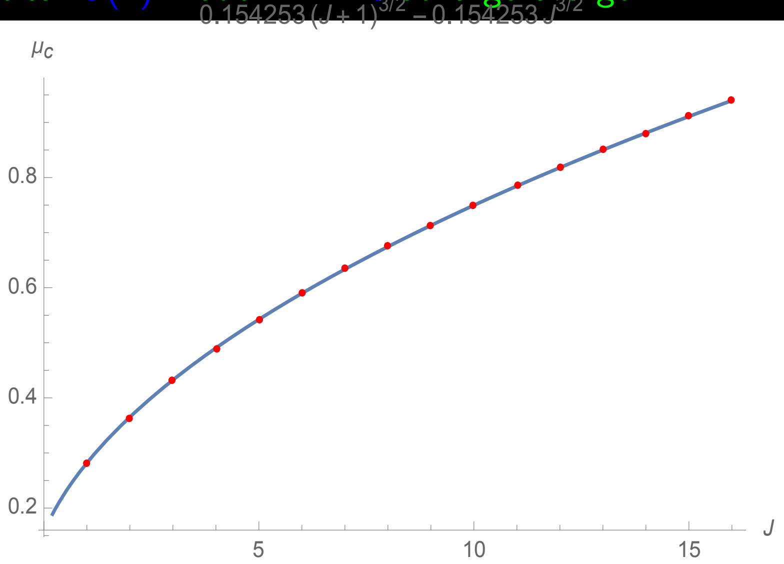


Here, we are plotting $\Delta_{J+1} - \Delta_J$ on the

Critical O(2) model in D=3 at large charge



Here, we are plotting $\Delta_{J+1} - \Delta_J$ on the vertical

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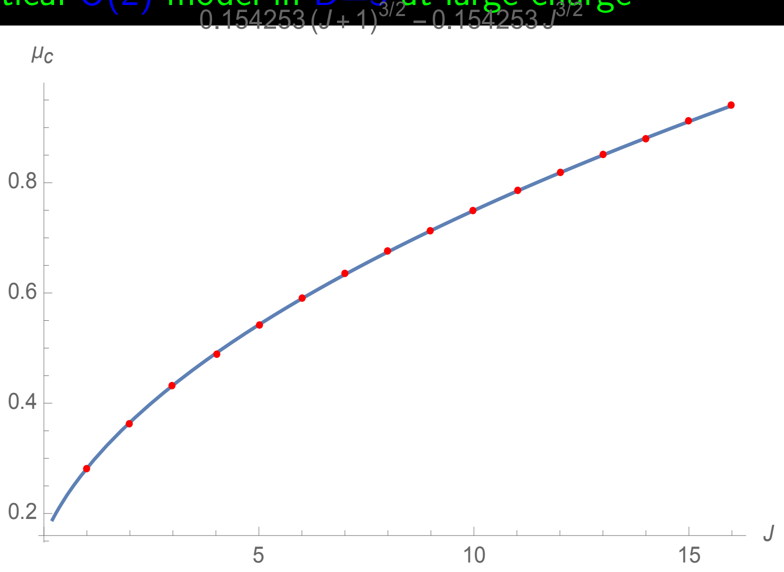

Here, we are plotting $\Delta_{J+1} - \Delta_J$ on the vertical axis,

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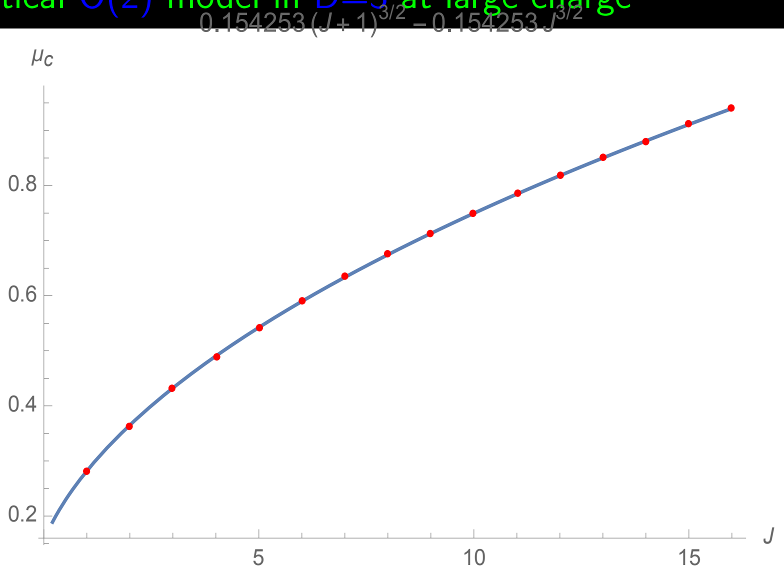
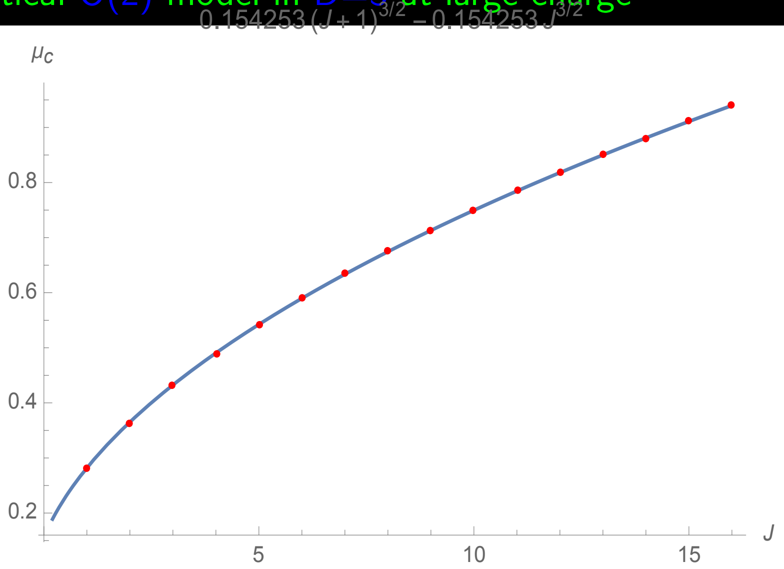


Here, we are plotting $\Delta_{J+1} - \Delta_J$ on the vertical axis, against J on the

Critical O(2) model in D=3 at large charge



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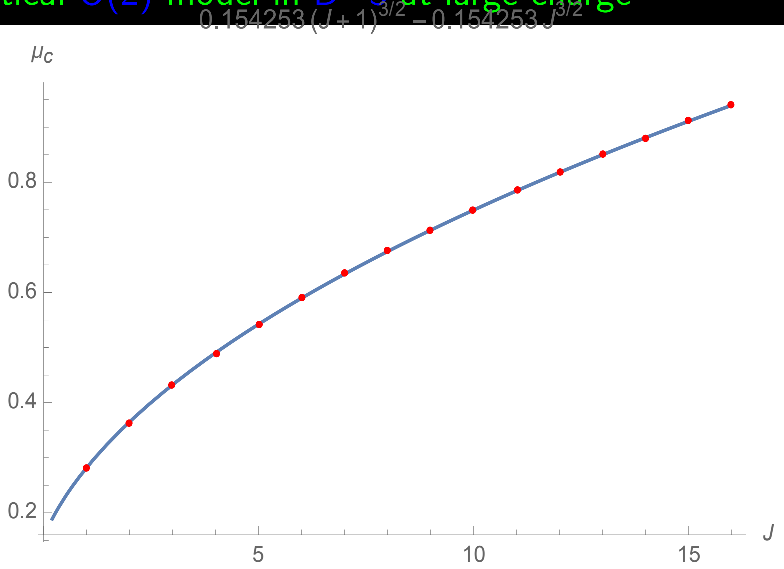

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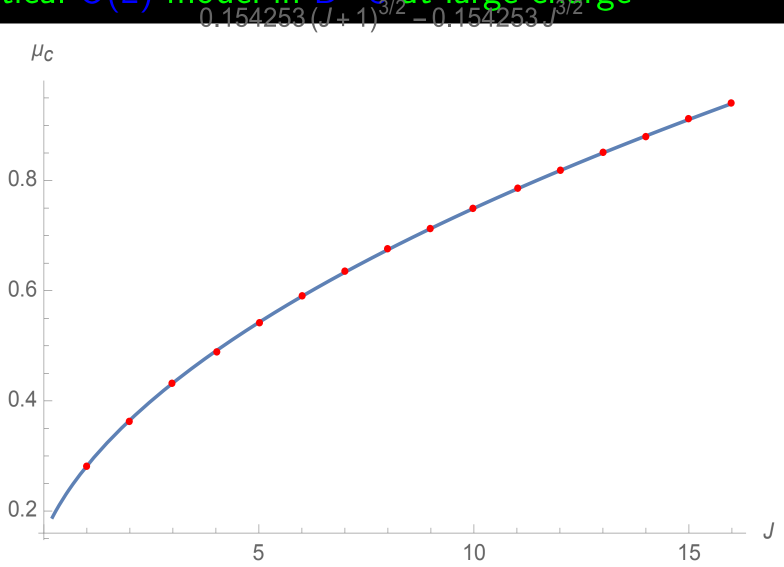

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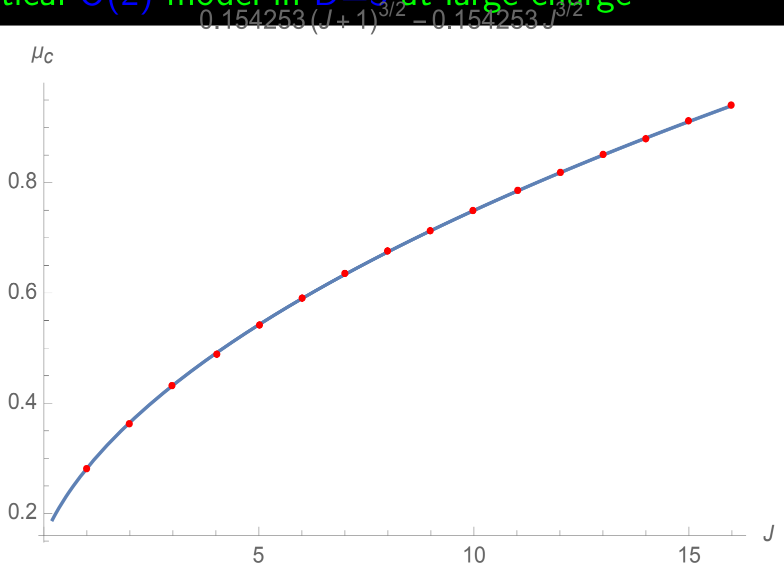

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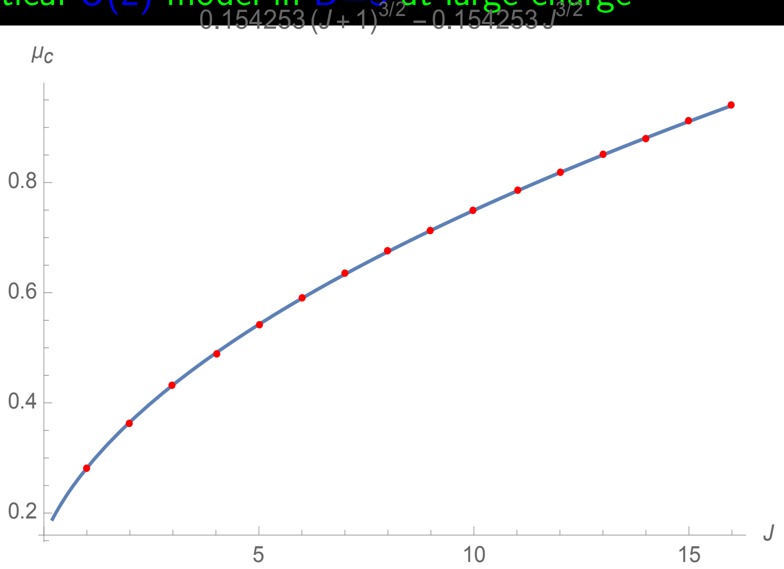
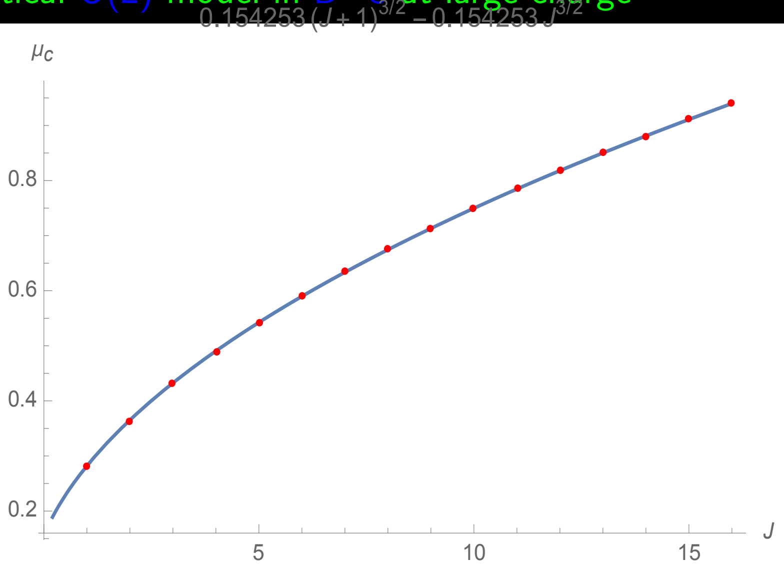


The red dots

Critical O(2) model in D=3 at large charge



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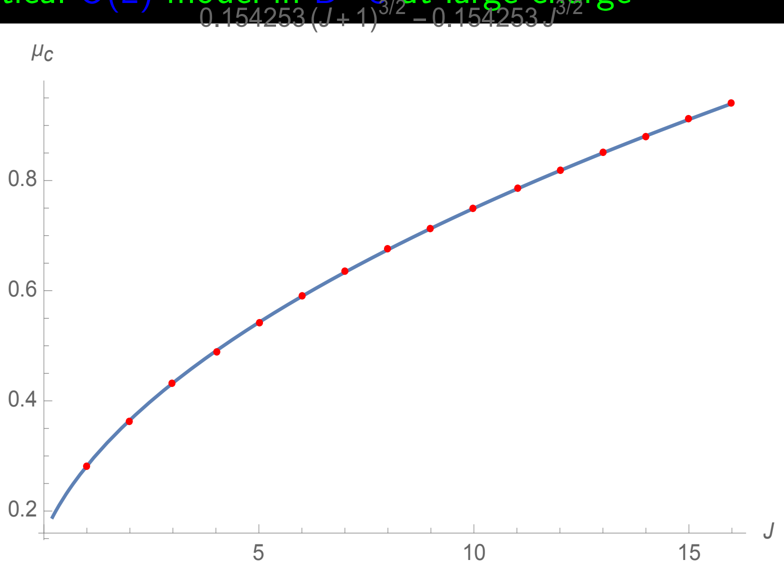

The red dots are the lattice data

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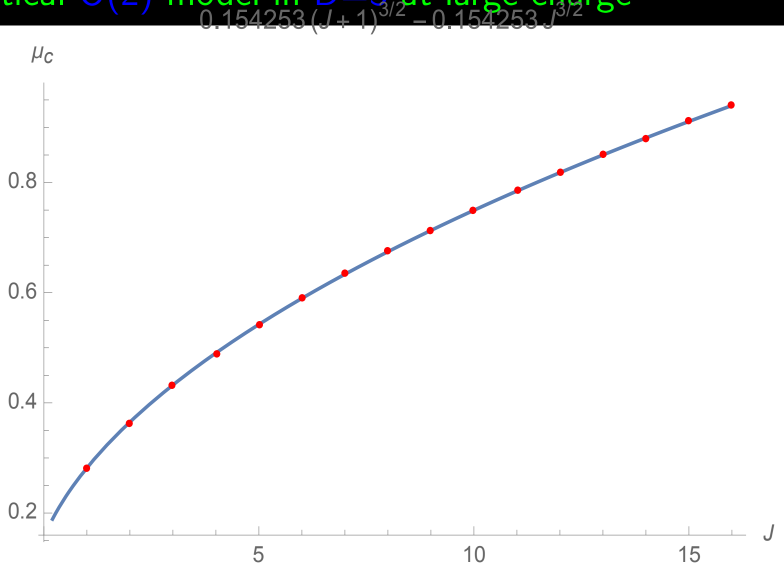

The red dots are the lattice data for the differences between adjacent

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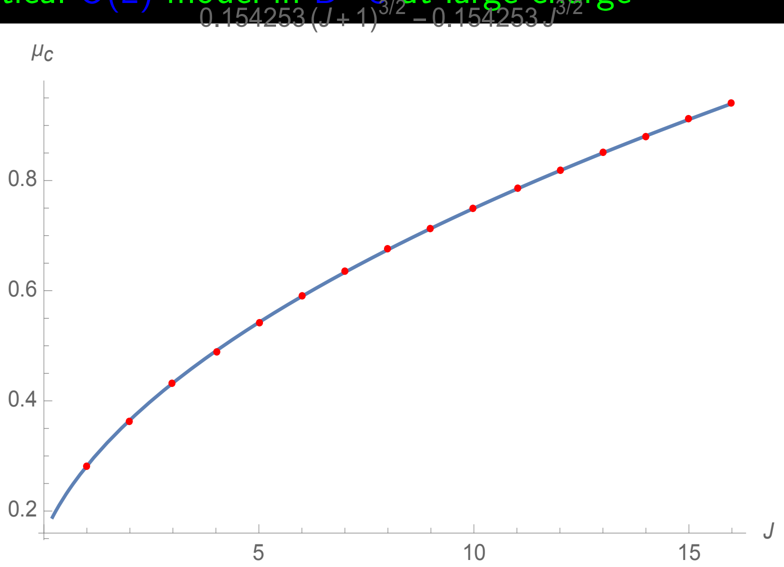

The red dots are the lattice data for the differences between adjacent charged ground states.

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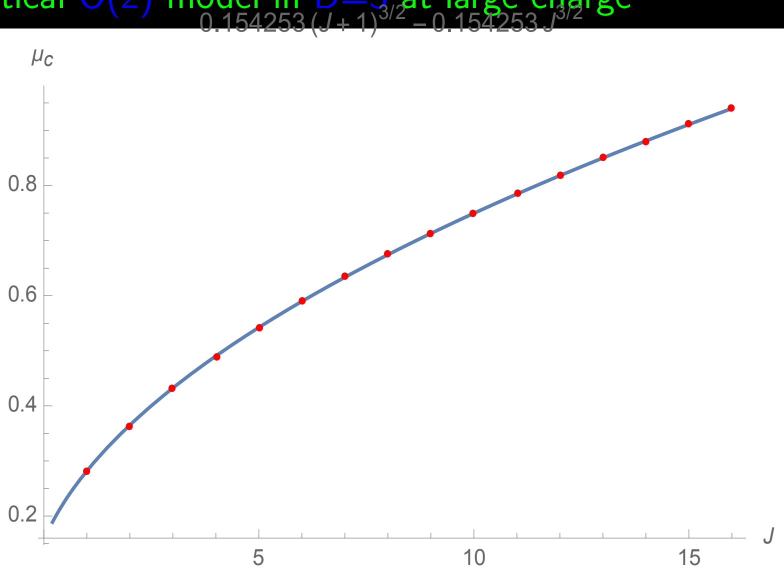

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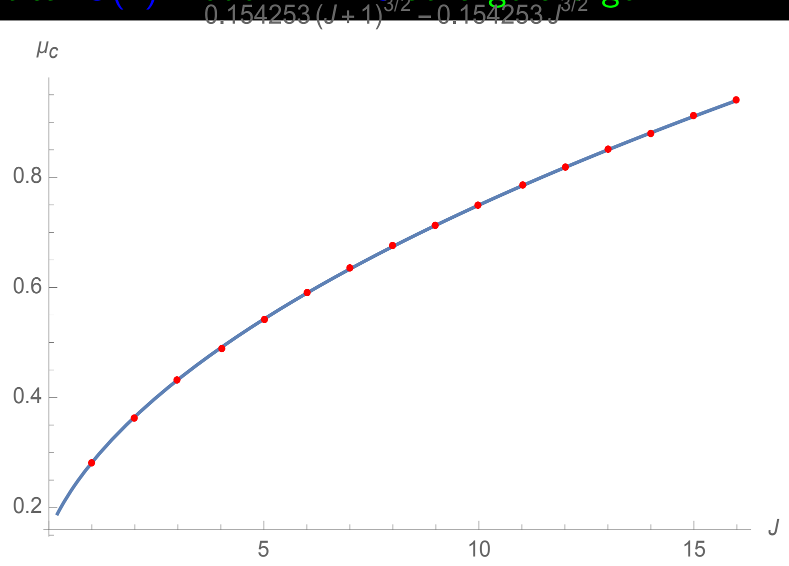

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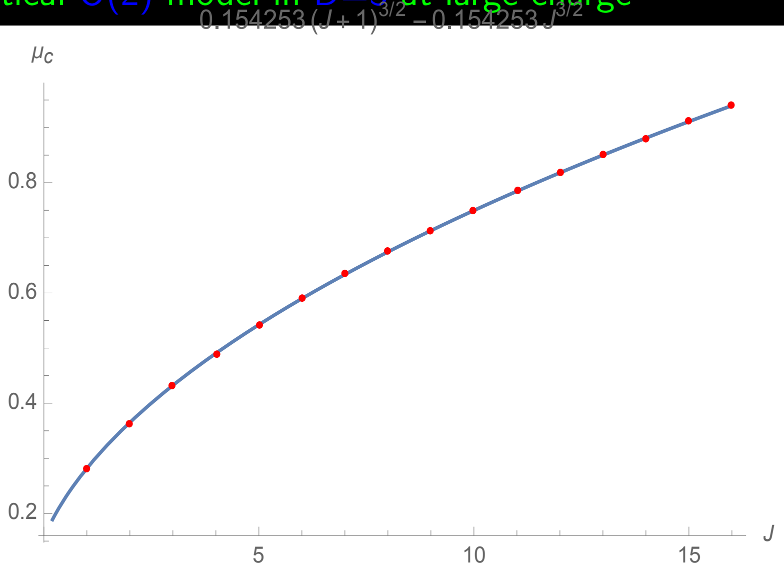

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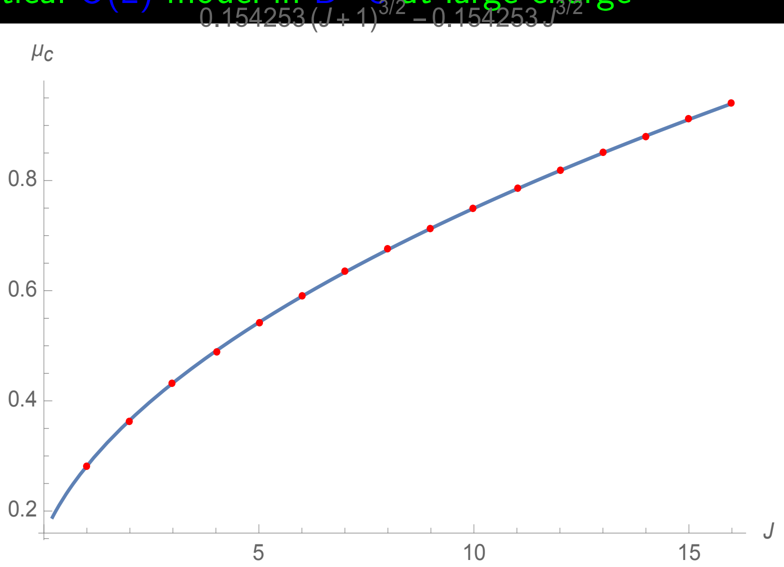
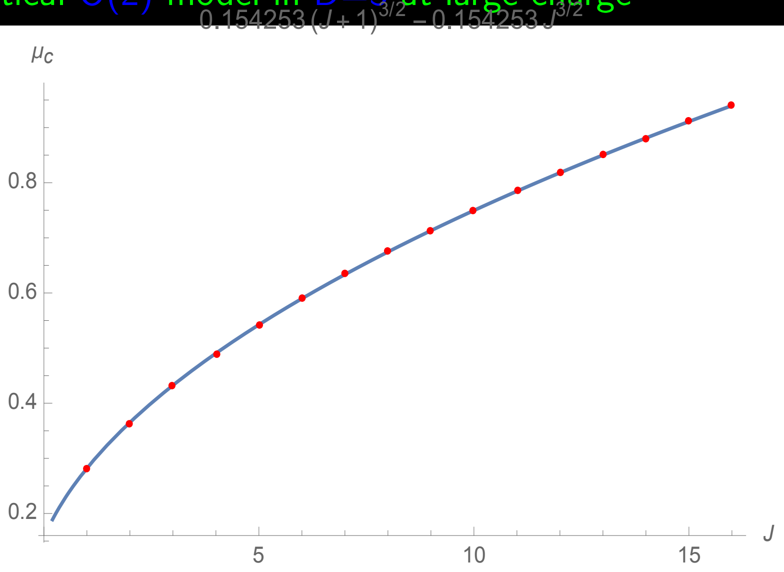


The blue curve

Critical O(2) model in D=3 at large charge



The blue curve is the

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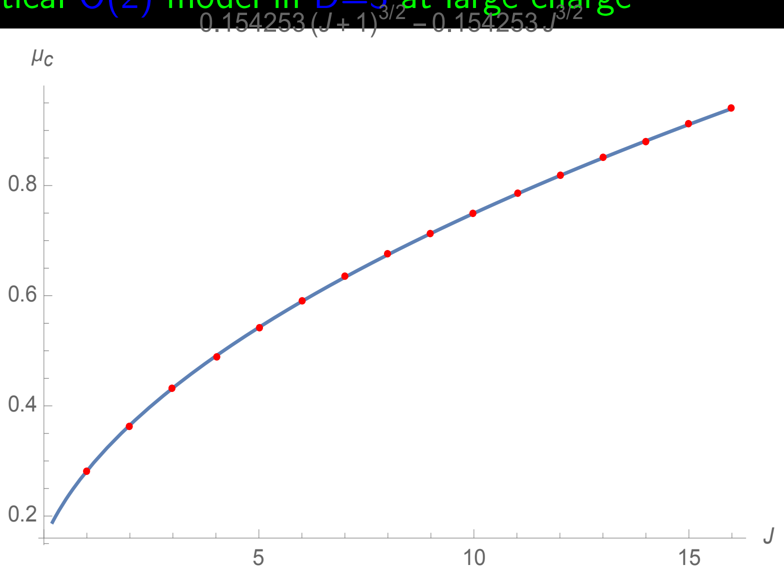
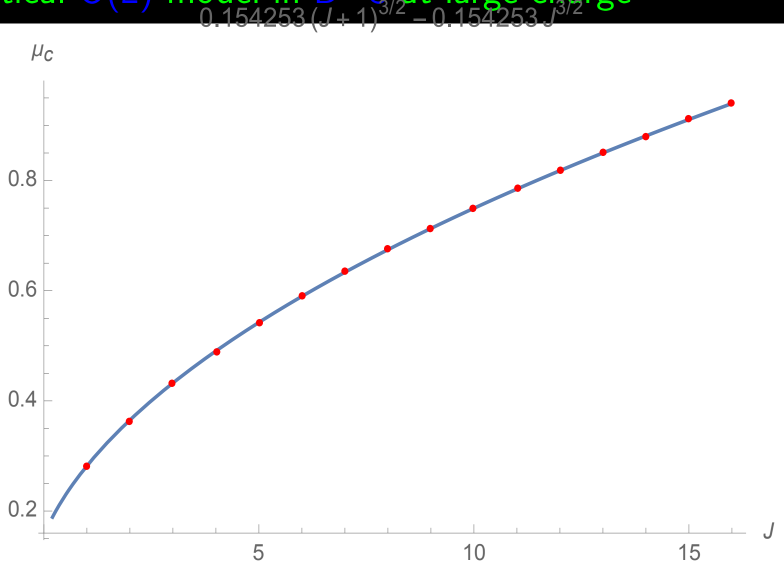


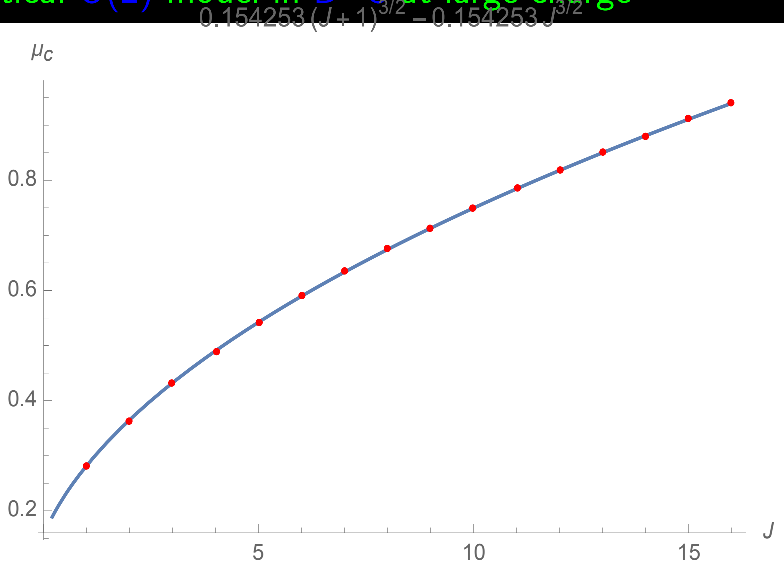
The blue curve is the theoretical prediction

Critical O(2) model in D=3 at large charge



The blue curve is the theoretical prediction for the energies at

Critical O(2) model in D=3 at large charge



The blue curve is the theoretical prediction for the energies at leading order in J.

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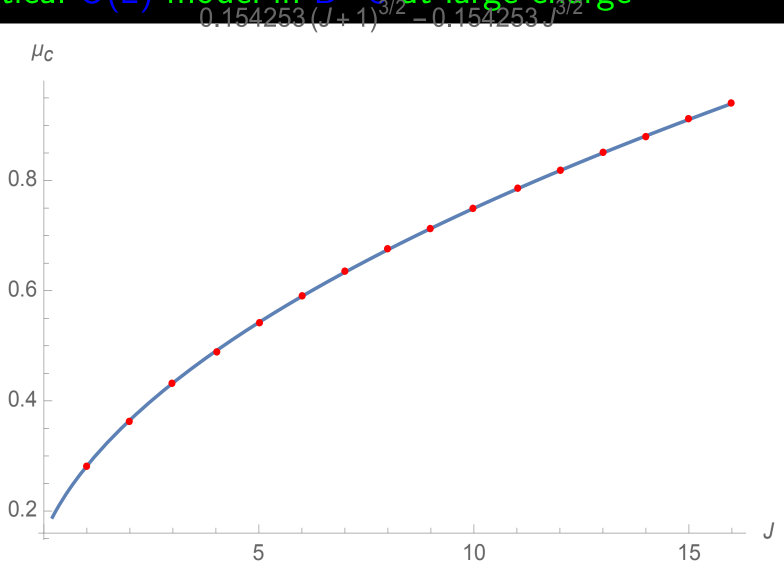

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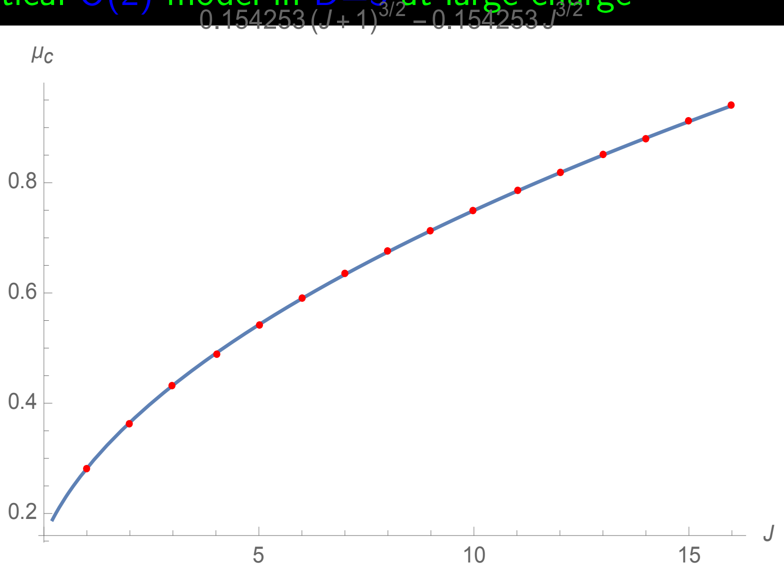

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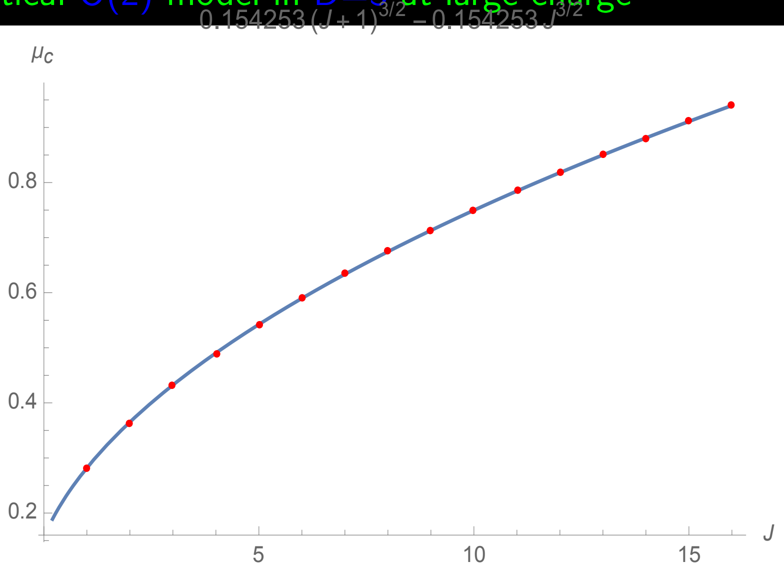

So

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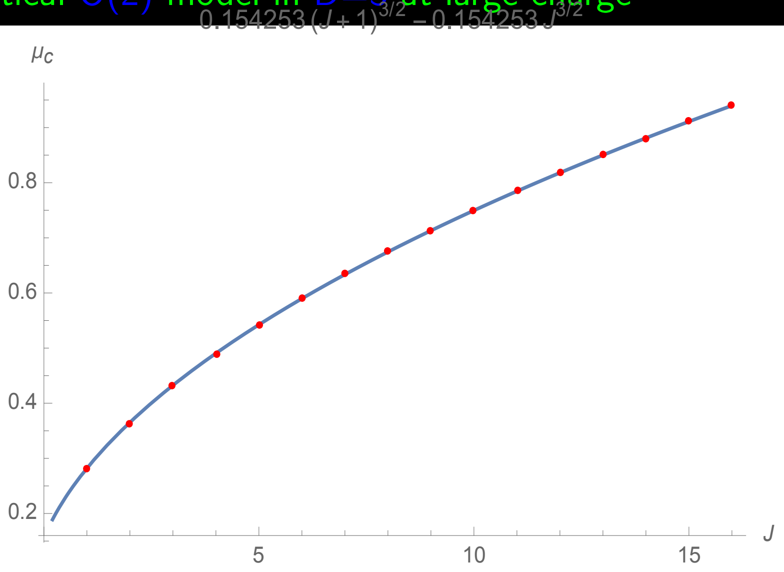

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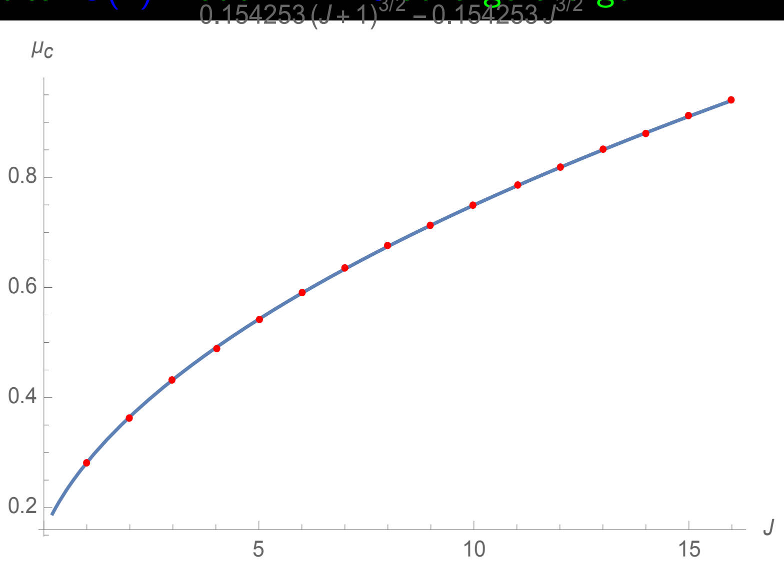

So ○ ○ ○○ ○ ○○ ○ ○ do you

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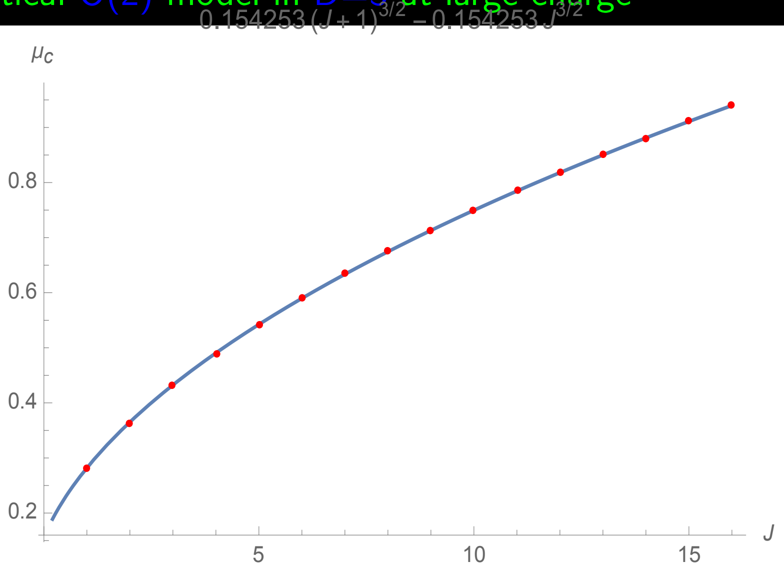

So ○ ○ ○○ ○ ○○ ○ ○ do you like it?

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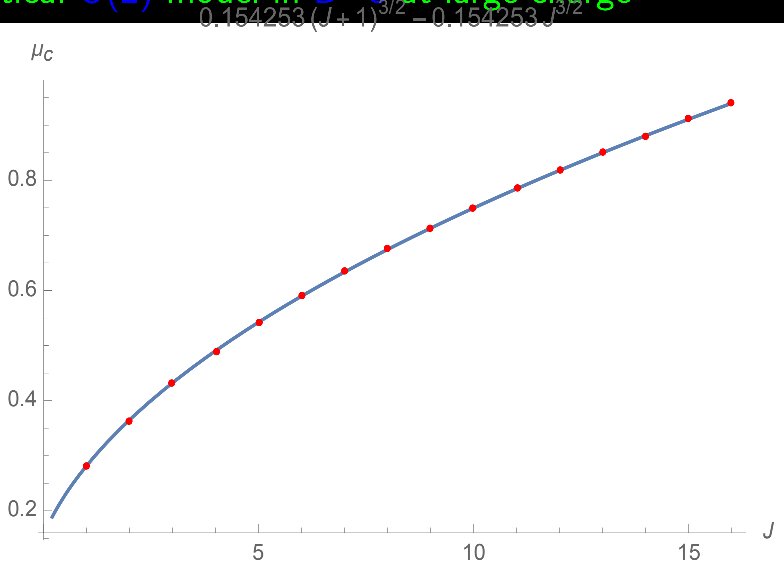

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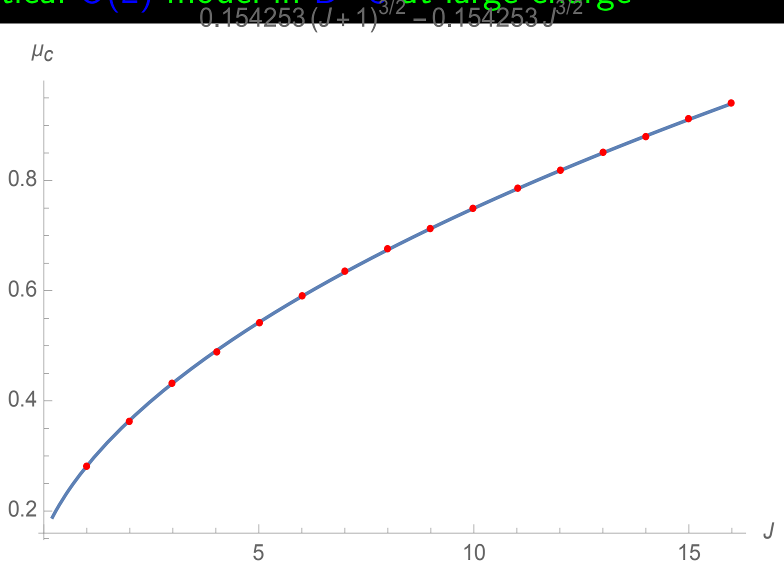

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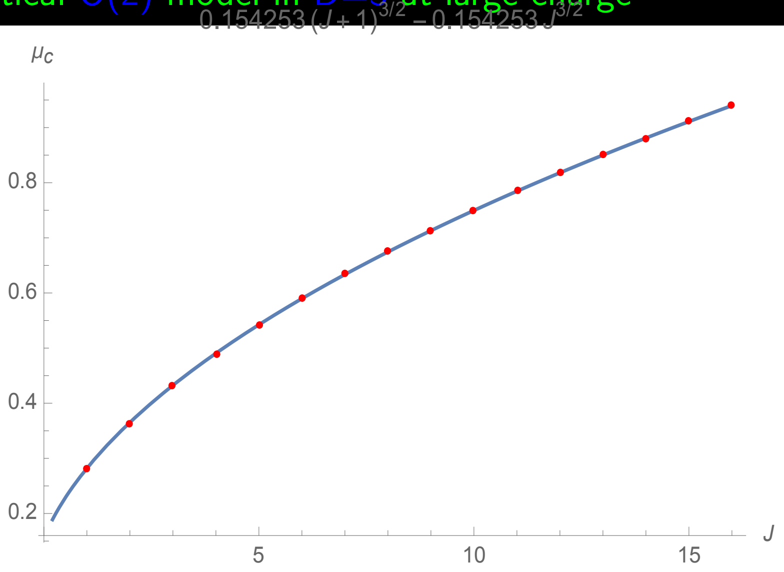

Because I'm pretty sure

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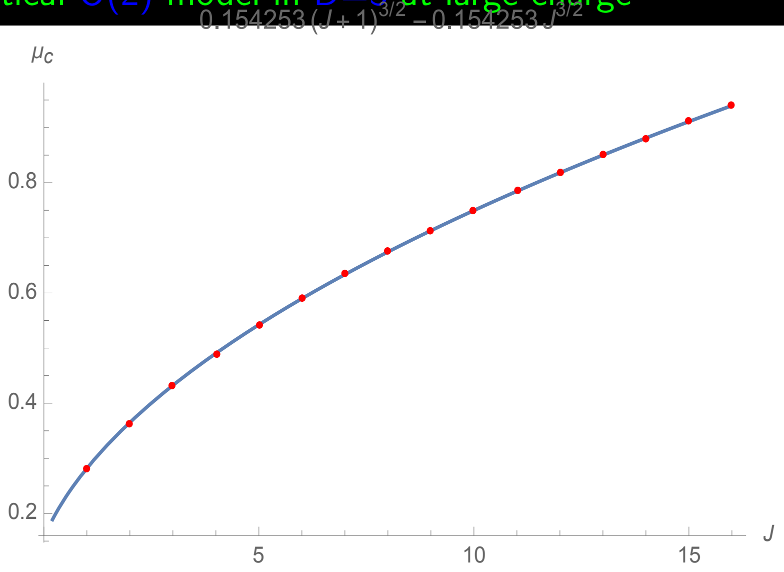

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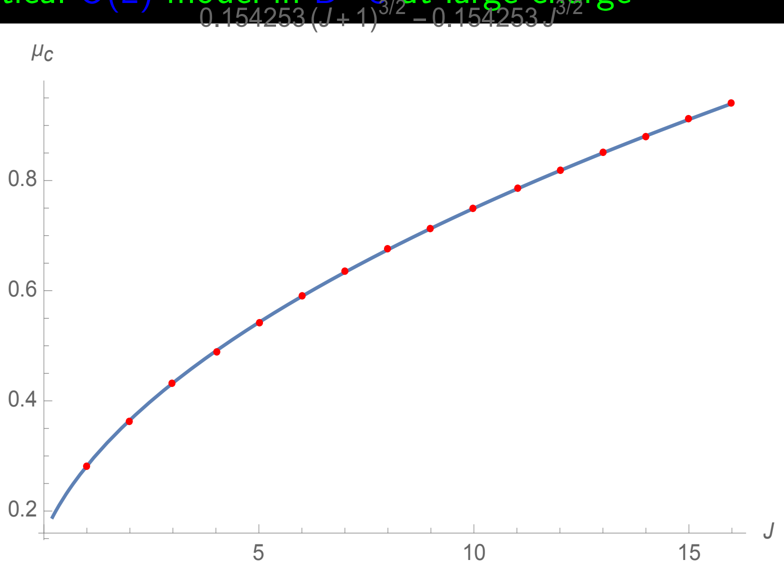

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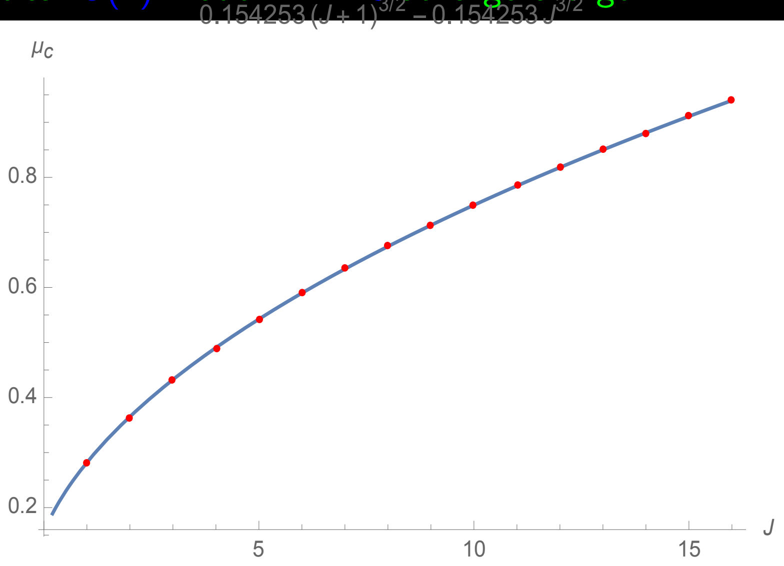

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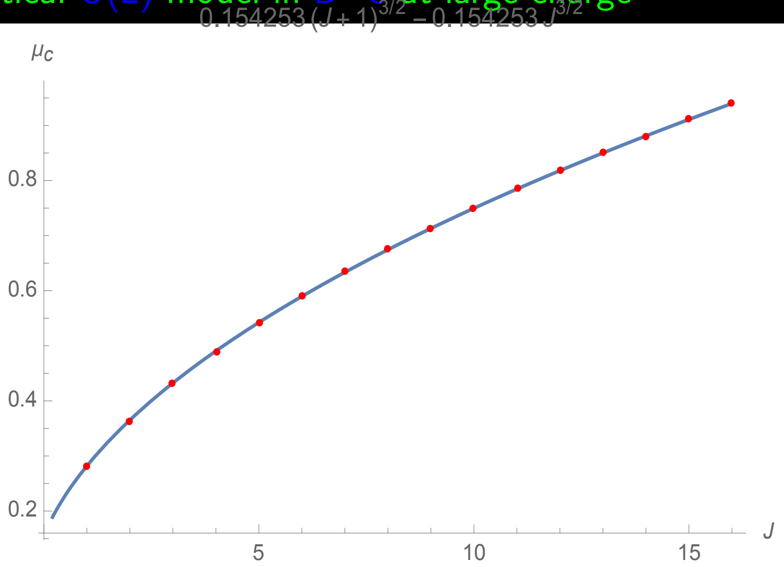

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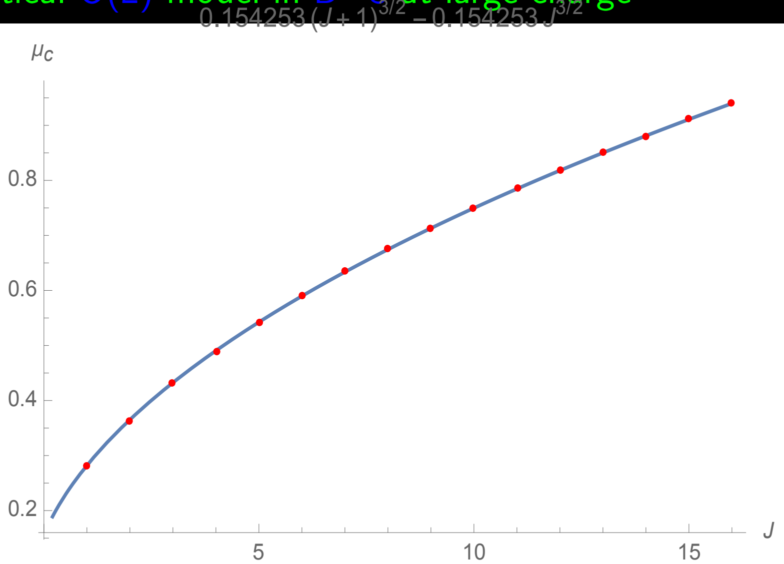

I want to emphasize that higher-derivative

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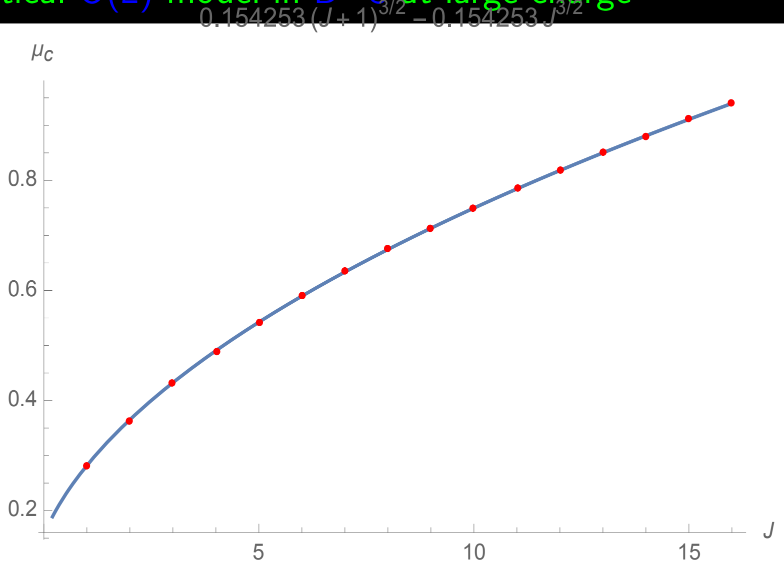

I want to emphasize that higher-derivative operators do not even enter the vacuum energy until order

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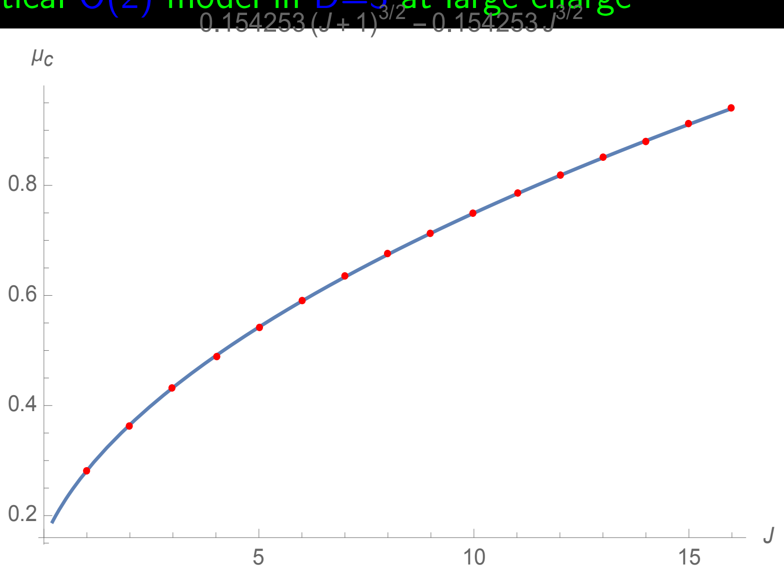

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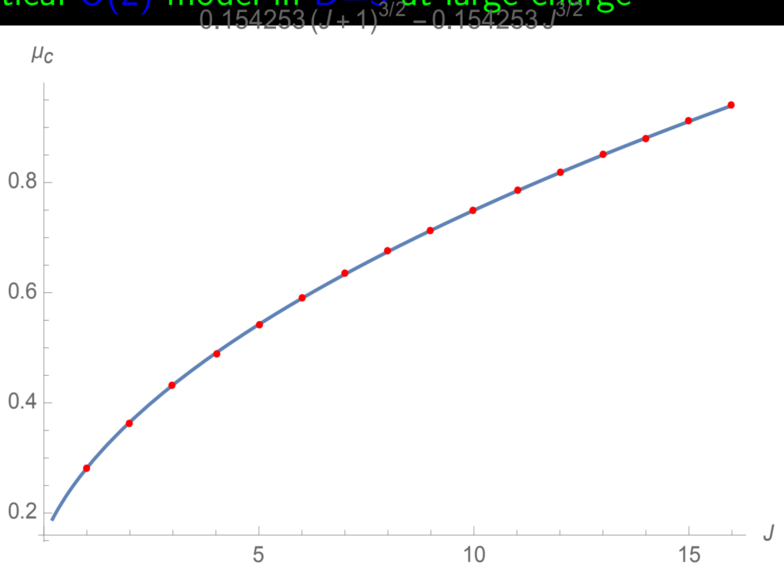

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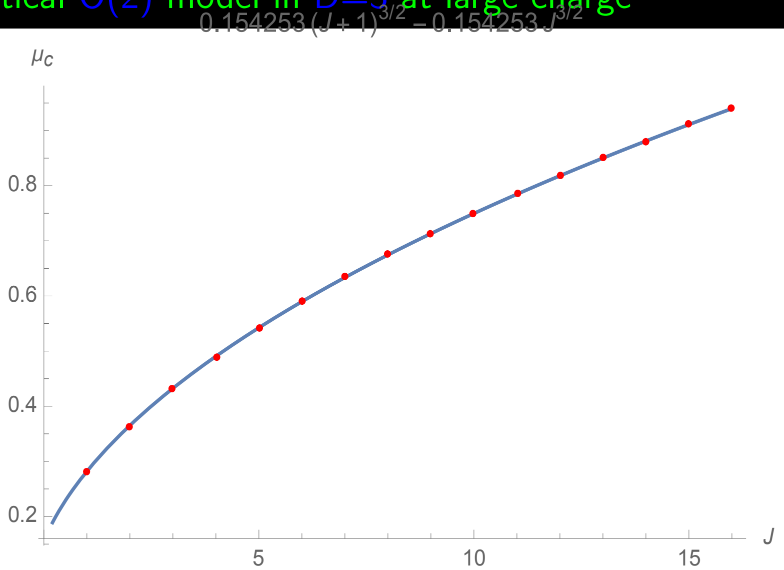

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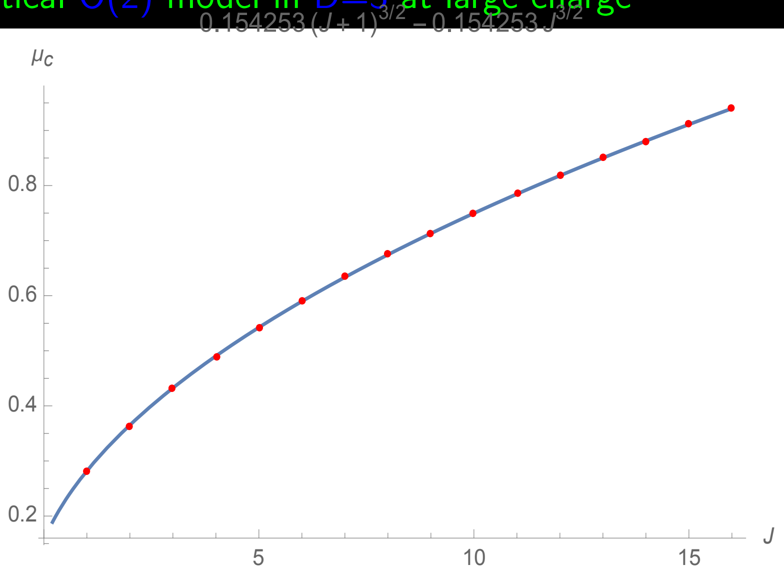

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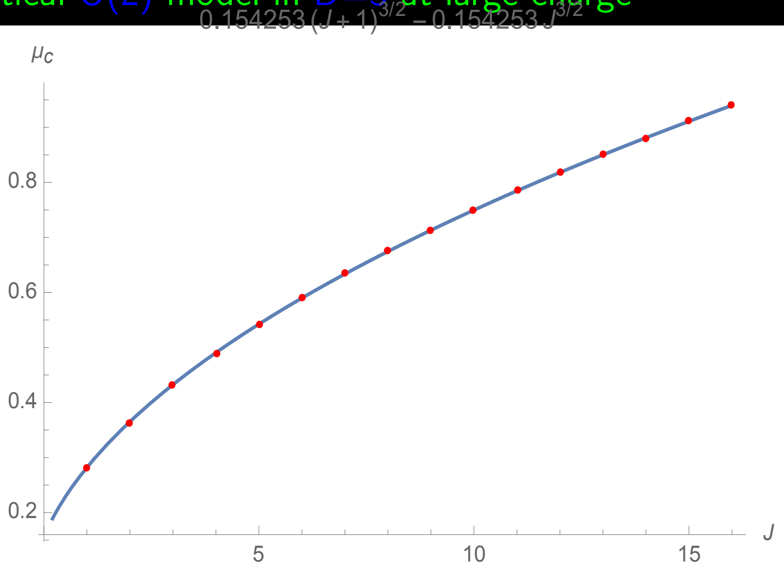

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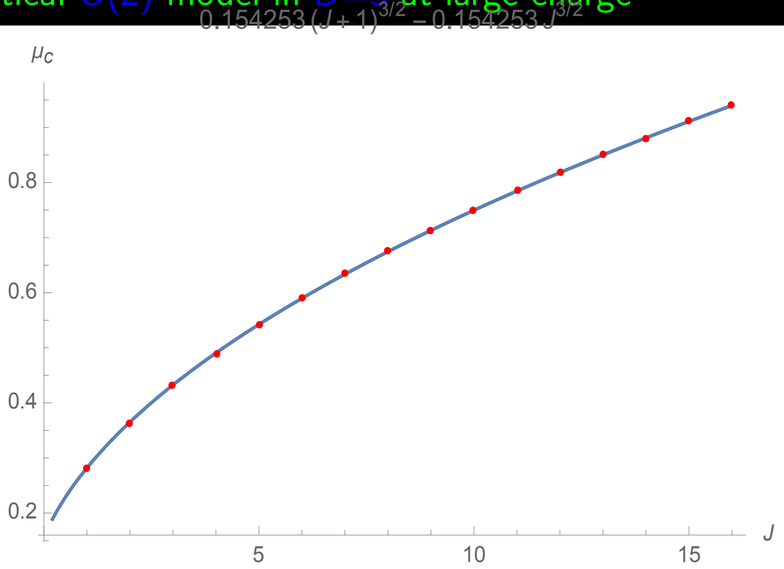

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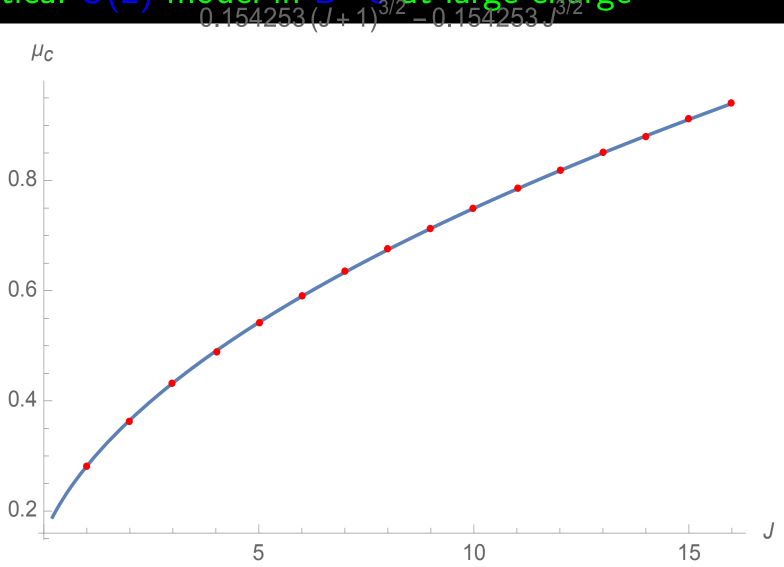

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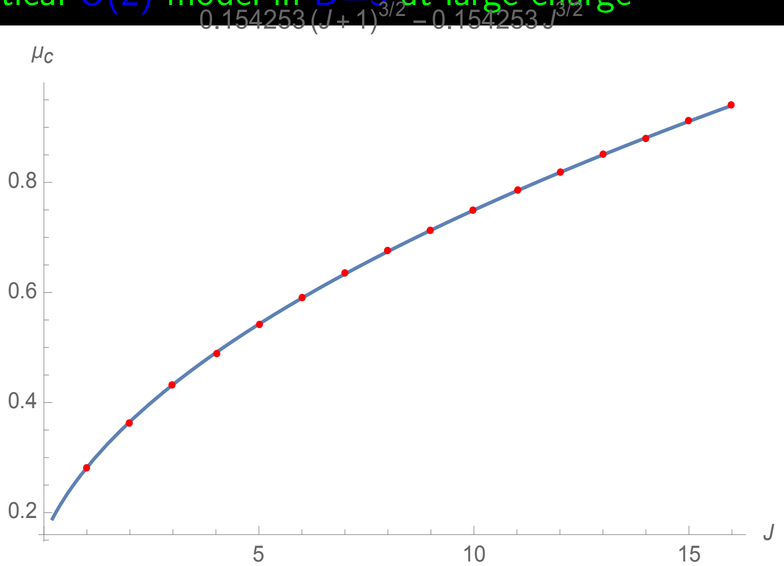

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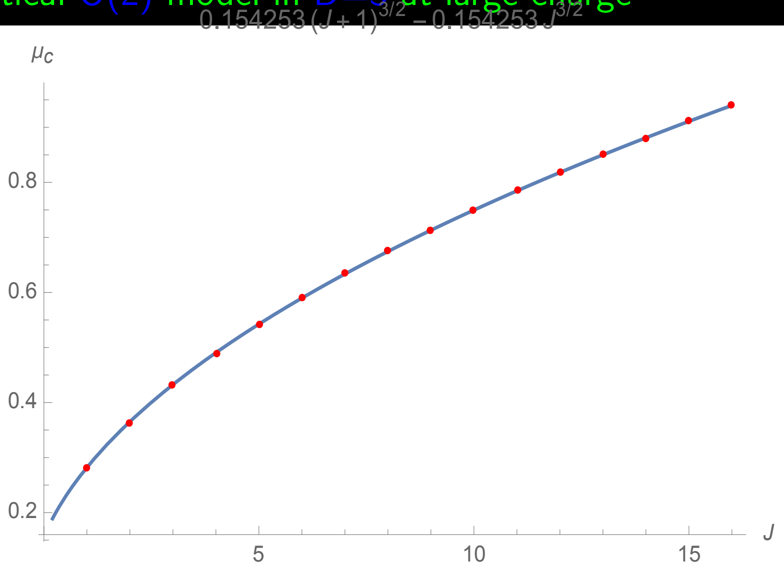

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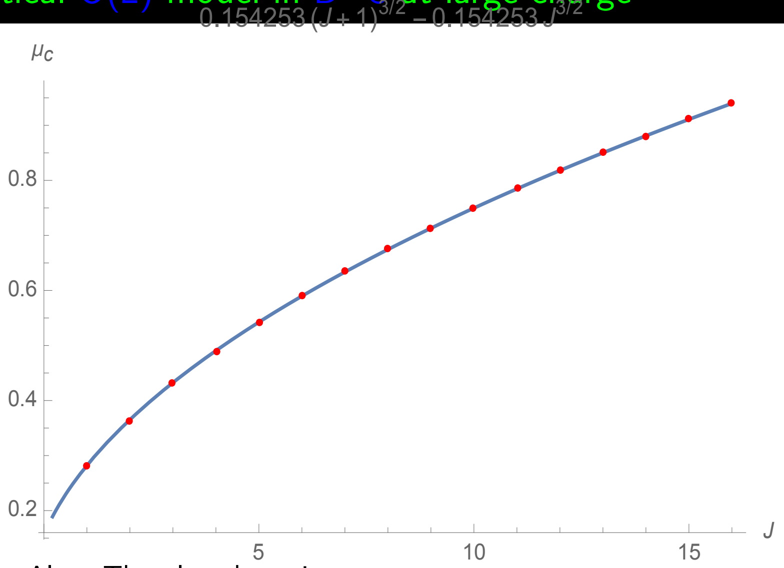

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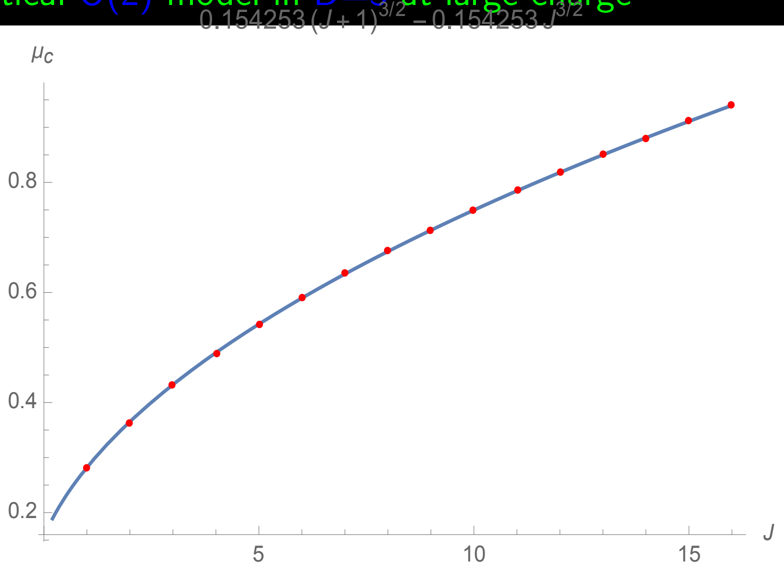

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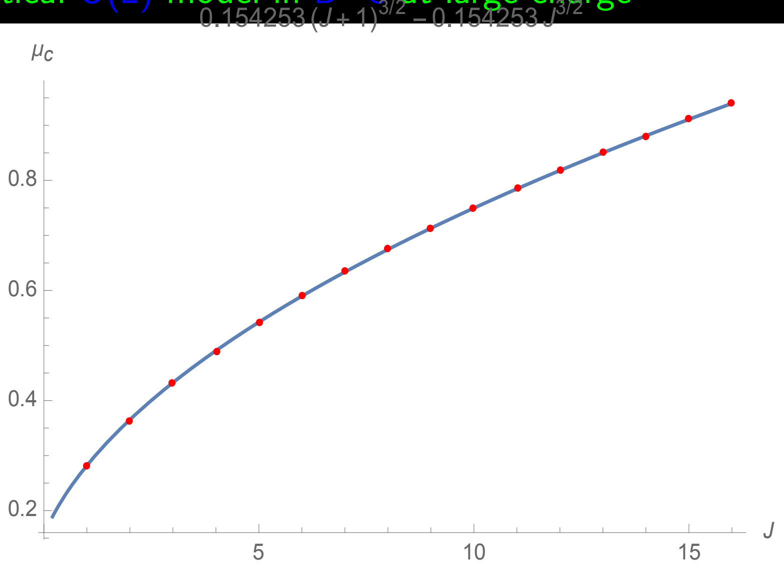

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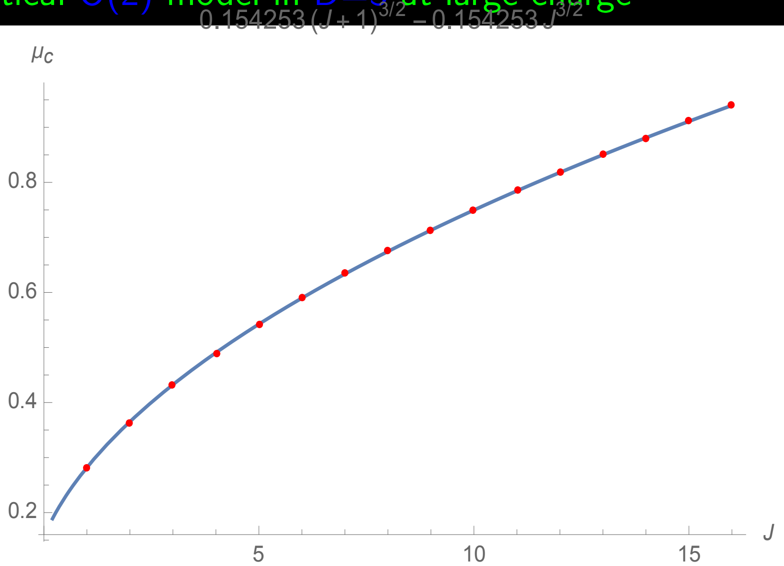

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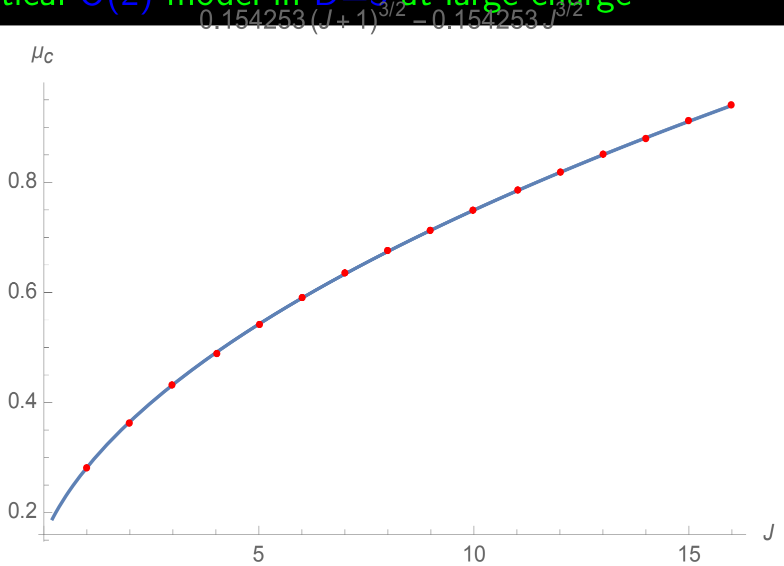

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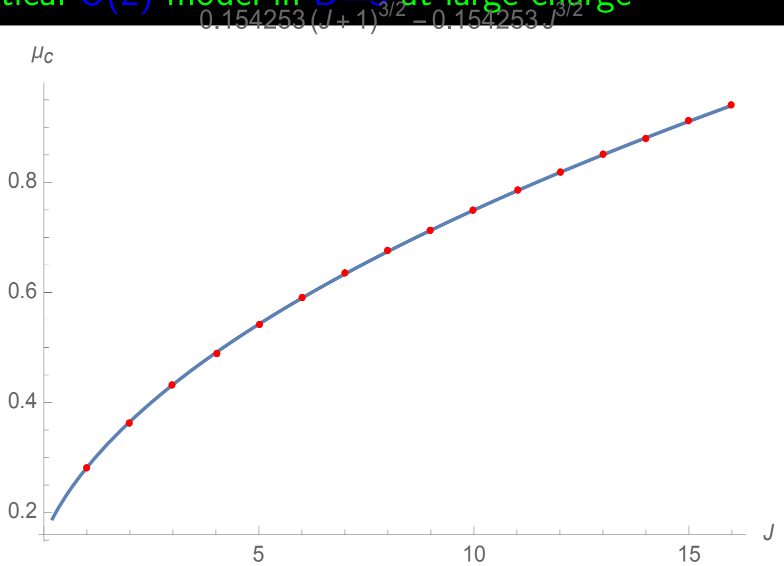

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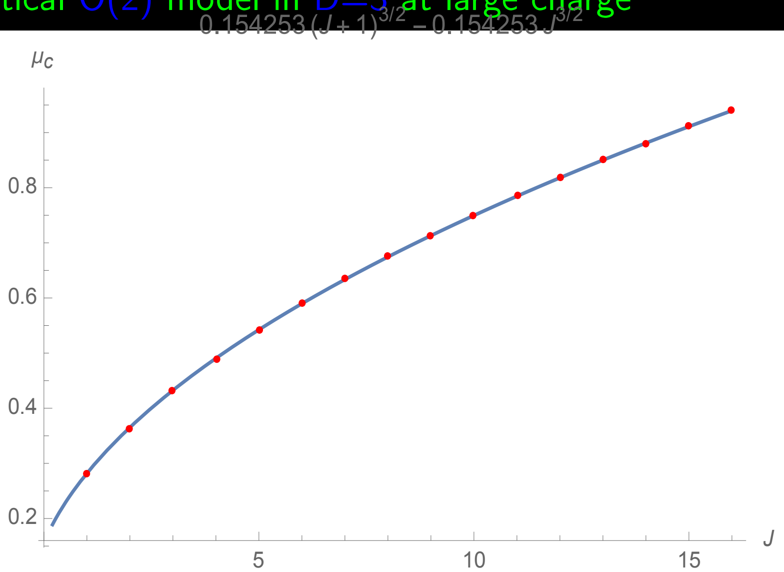

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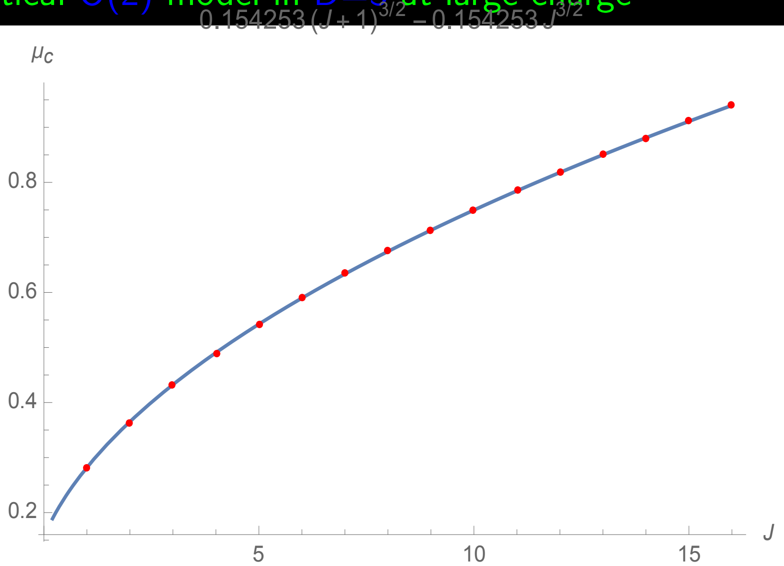

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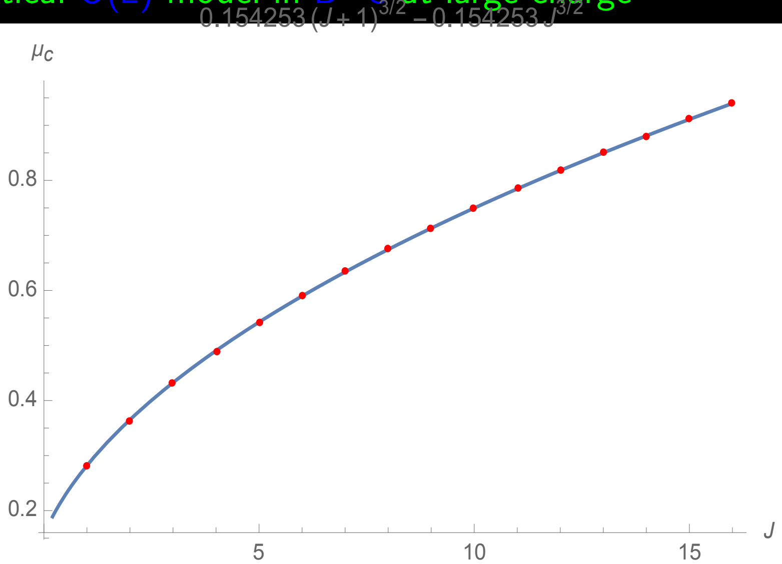

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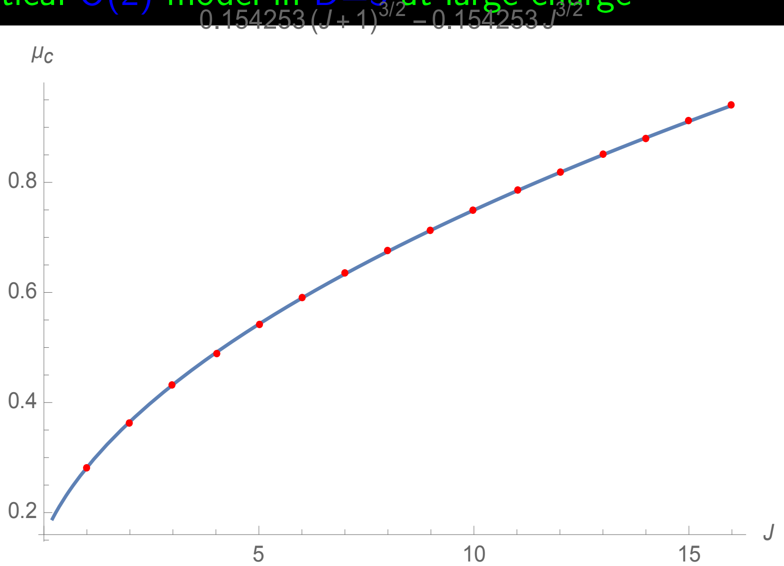

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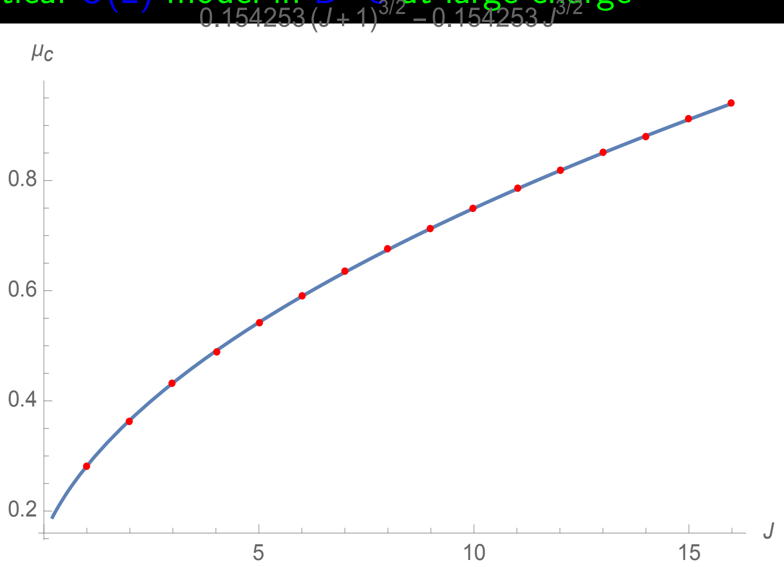

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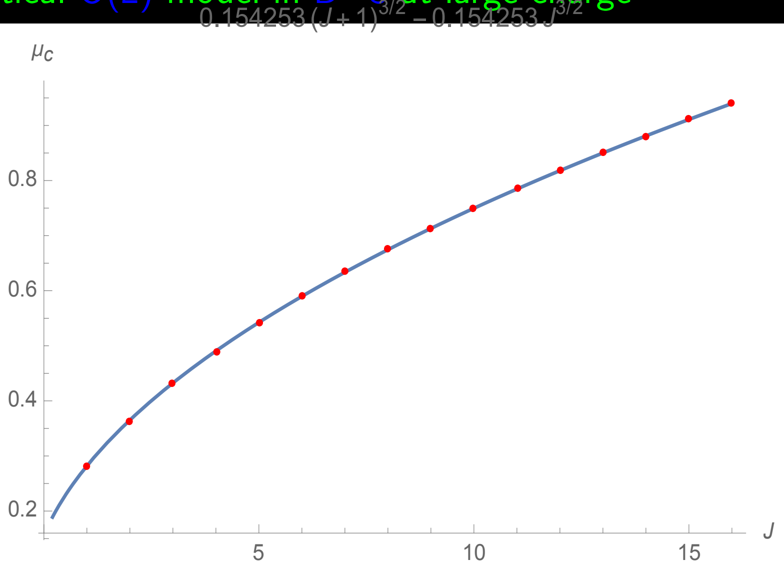

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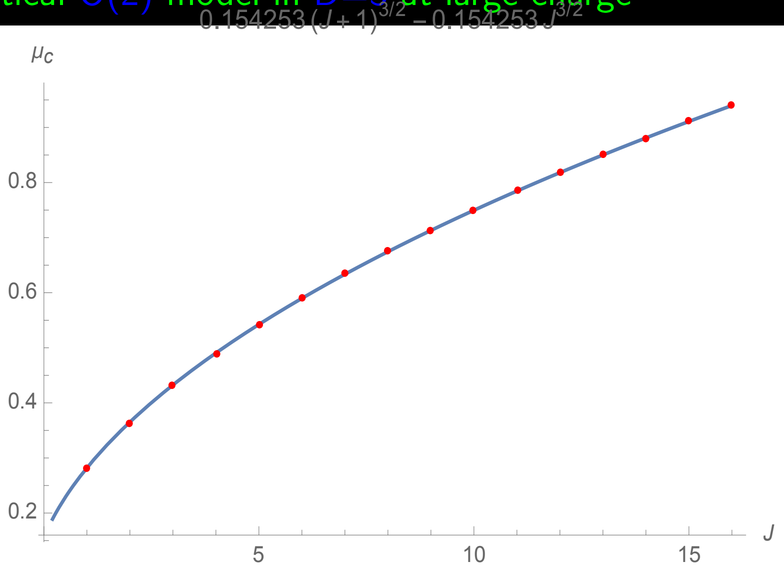

By fitting that single data point,

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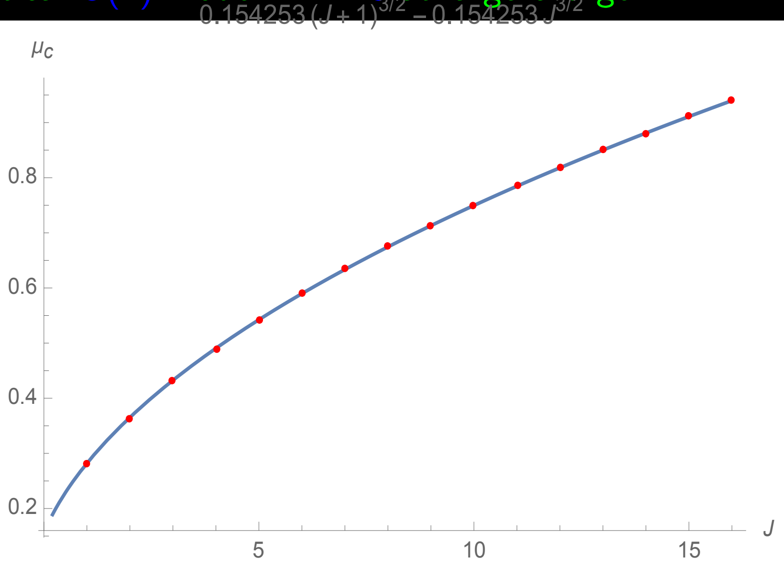

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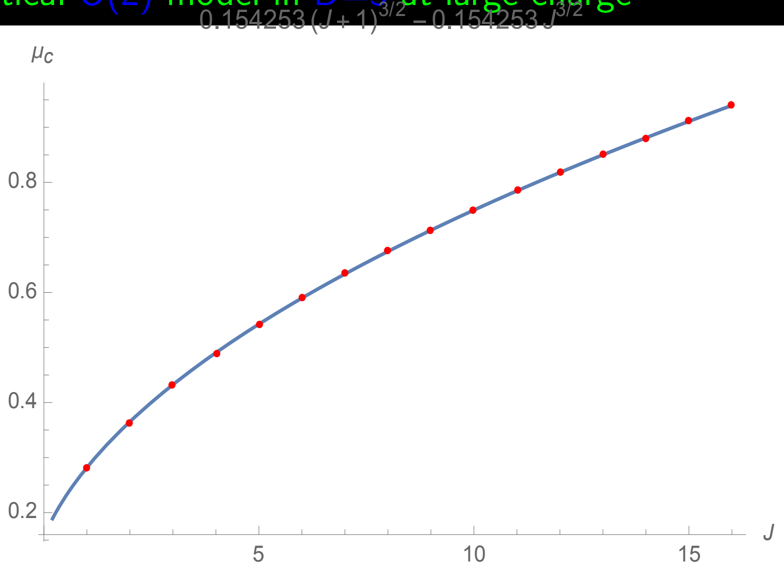
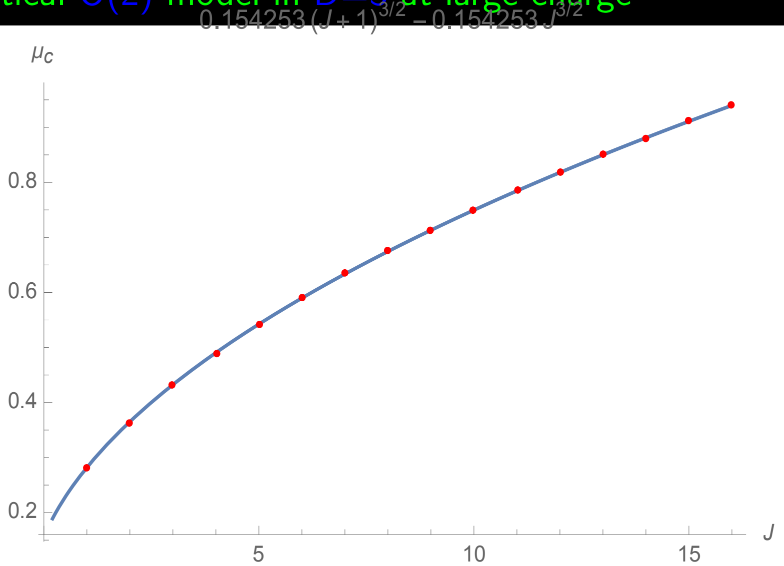
Critical O(2) model in D=3 at large charge



By fitting that single data point, the curve for the leading-order prediction

Critical O(2) model in D=3 at large charge



By fitting that single data point, the curve for the leading-order prediction runs more or less

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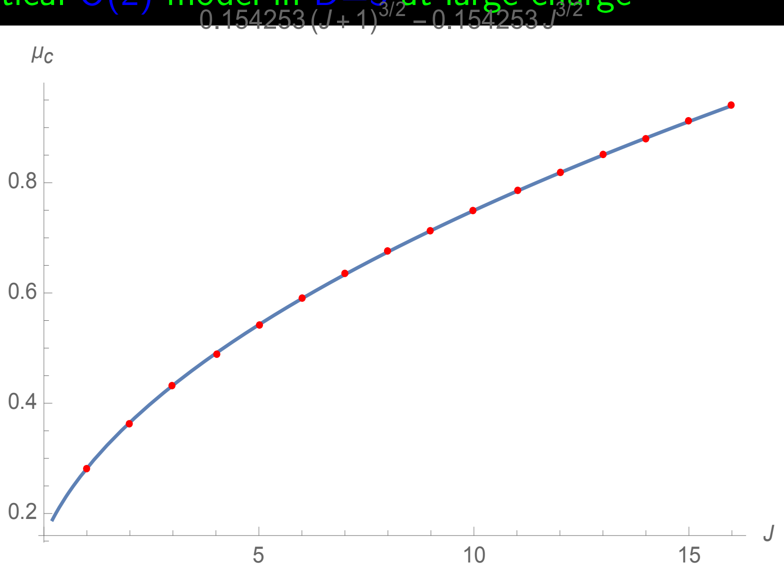
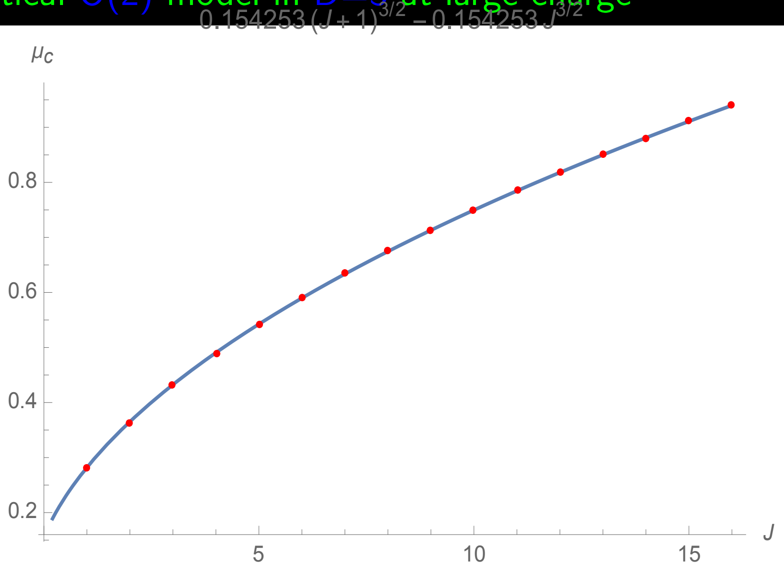


By fitting that single data point, the curve for the leading-order prediction runs more or less*

Critical O(2) model in D=3 at large charge



By fitting that single data point, the curve for the leading-order prediction runs more or less* perfectly

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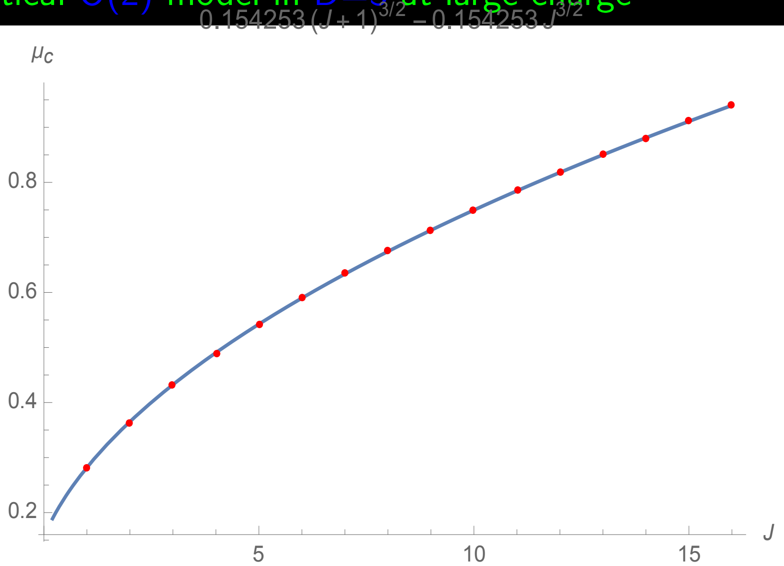
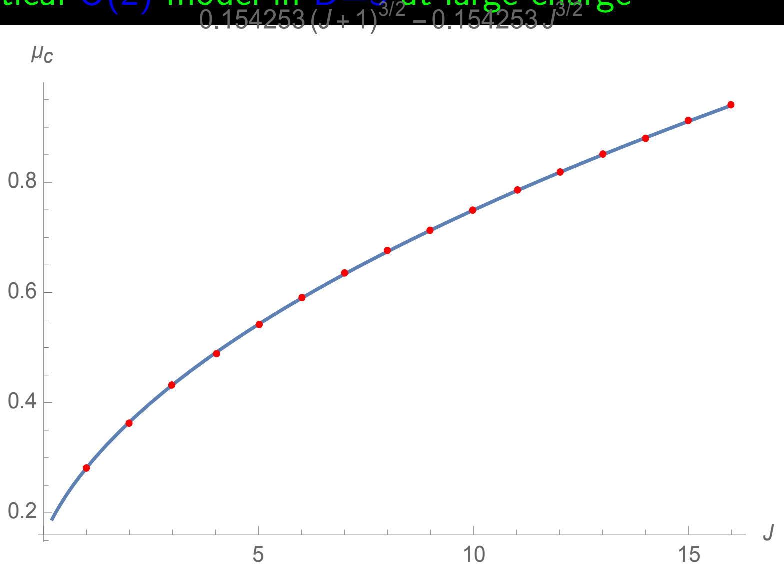


By fitting that single data point, the curve for the leading-order prediction runs more or less* perfectly through all the existing data,

Critical O(2) model in D=3 at large charge



By fitting that single data point, the curve for the leading-order prediction runs more or less* perfectly through all the existing data, down to

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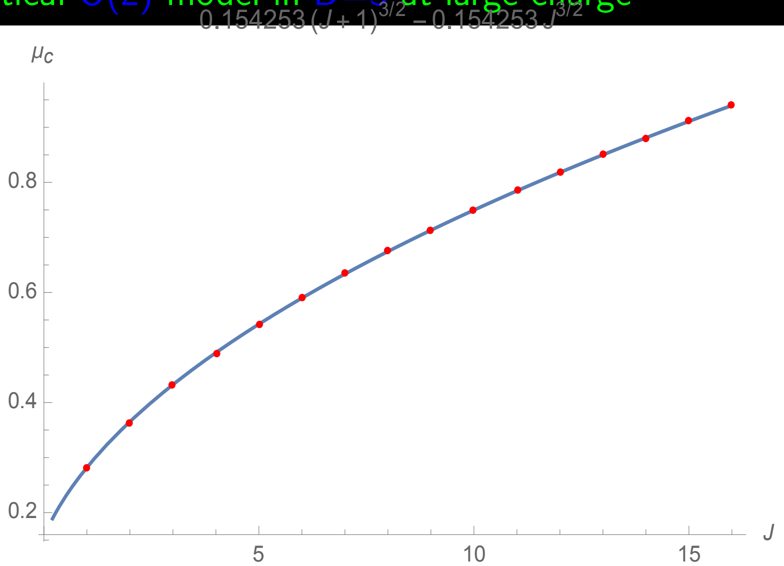

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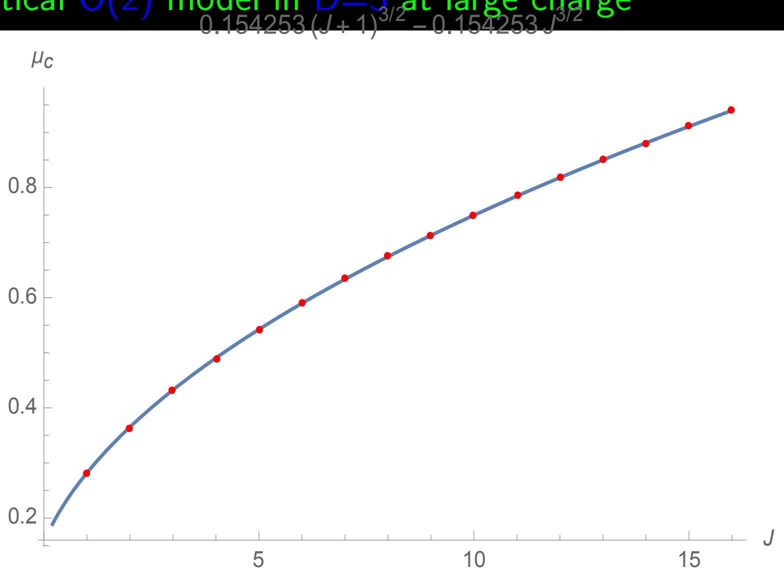

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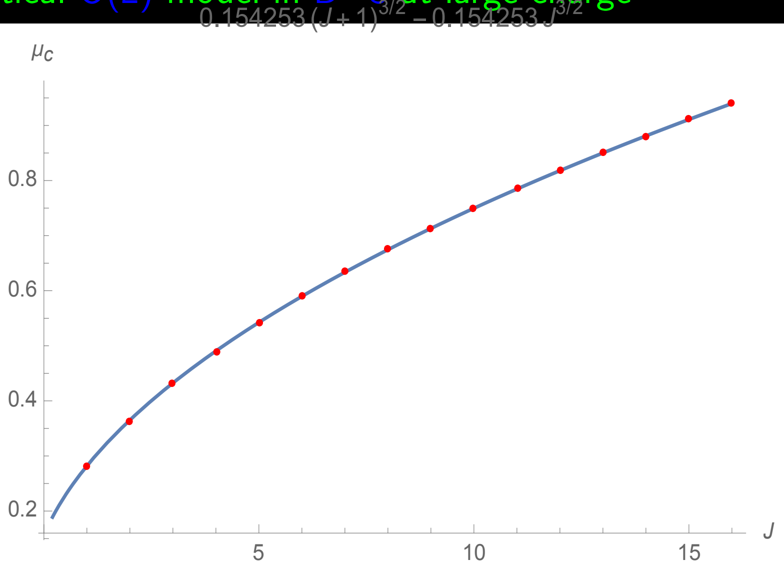

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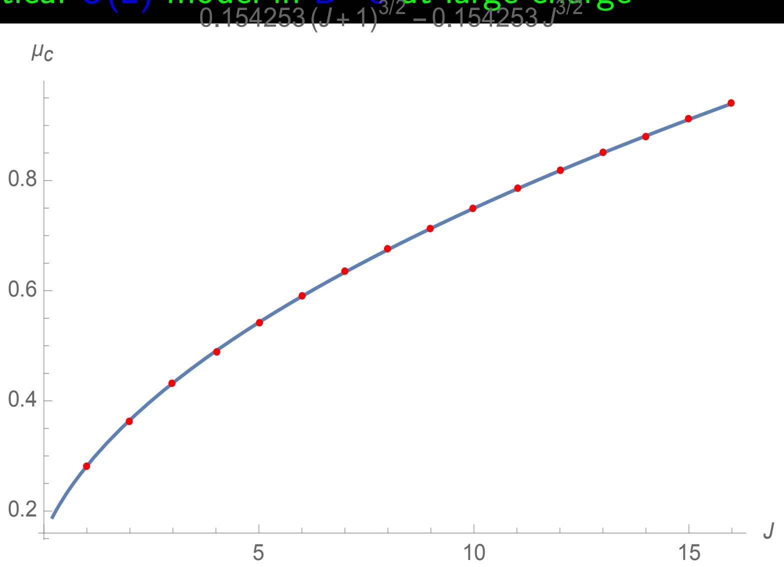

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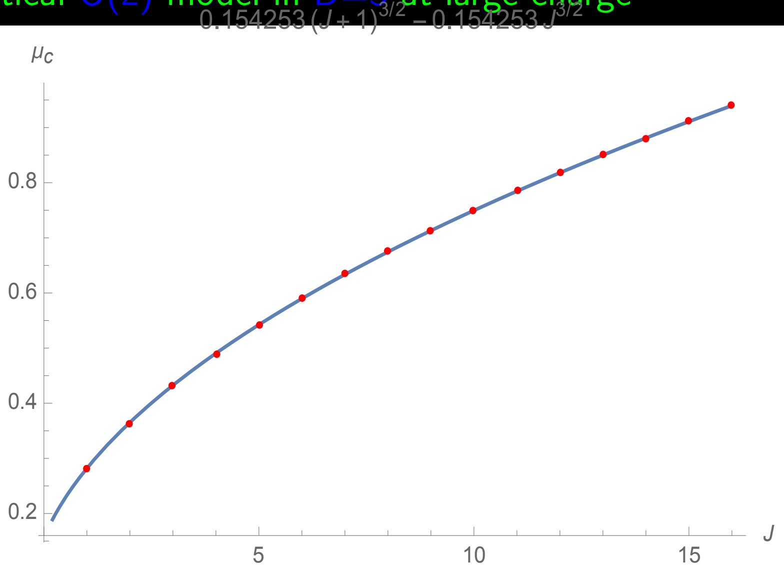

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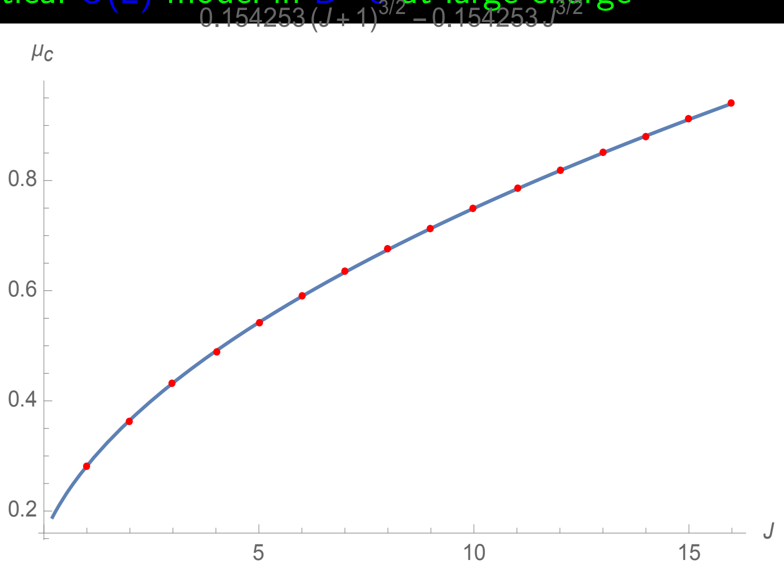

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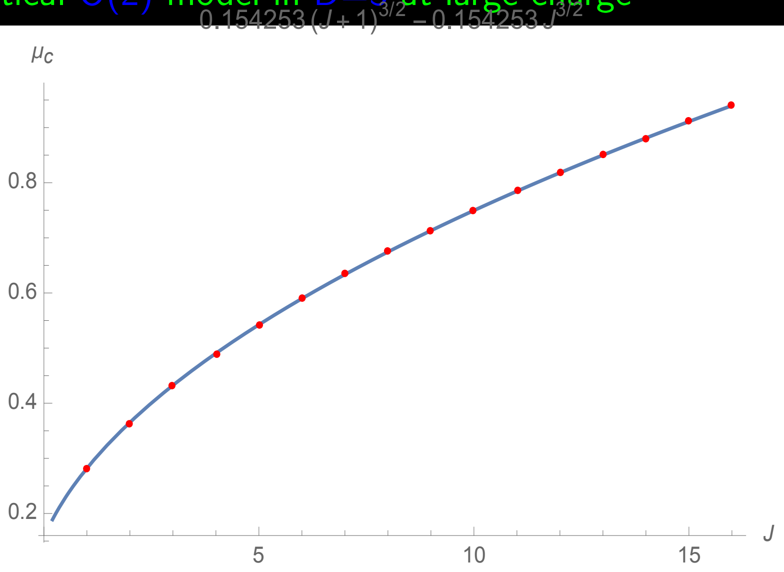

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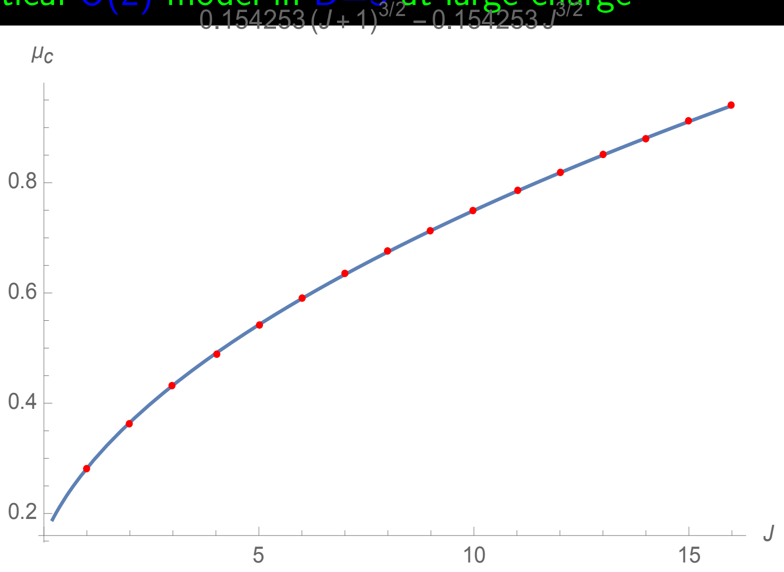

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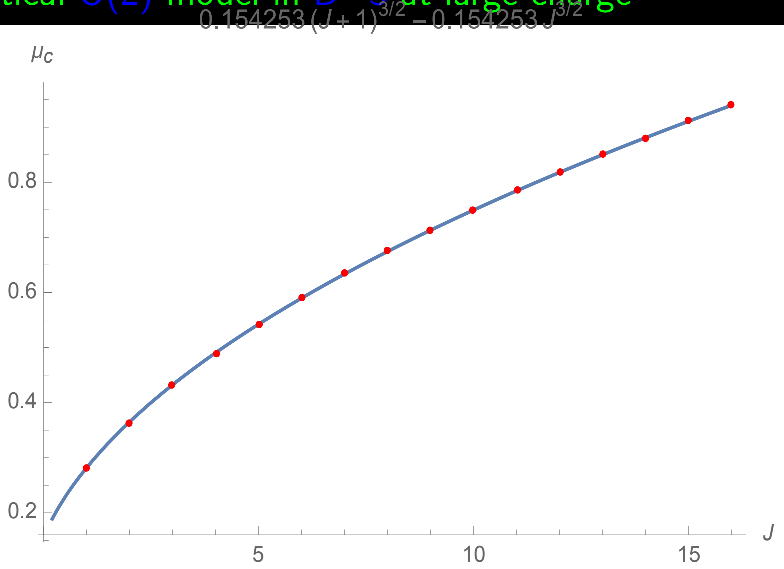

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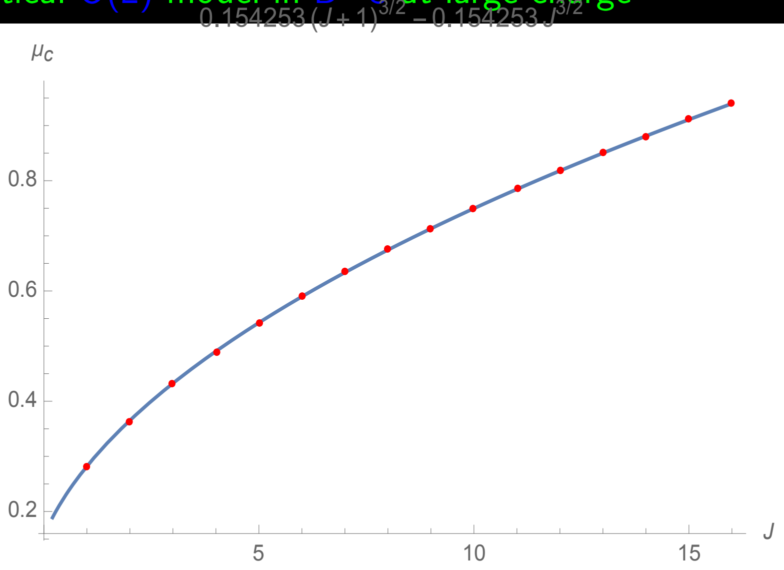

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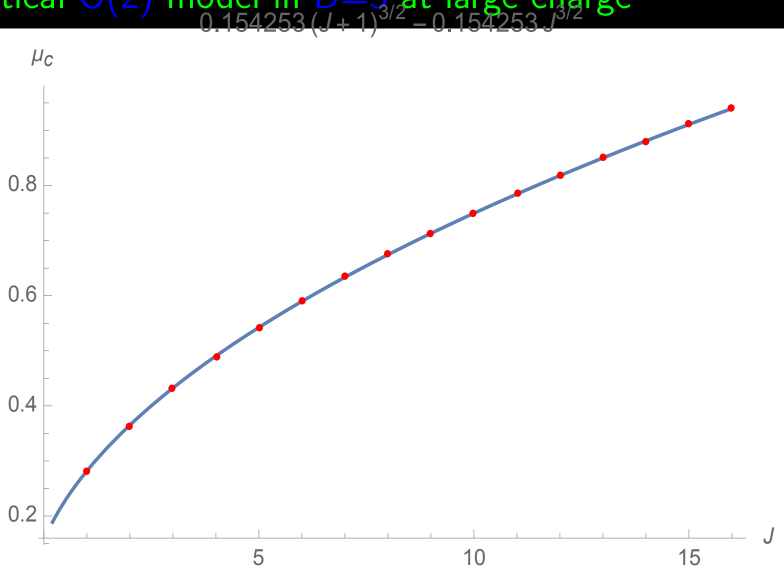

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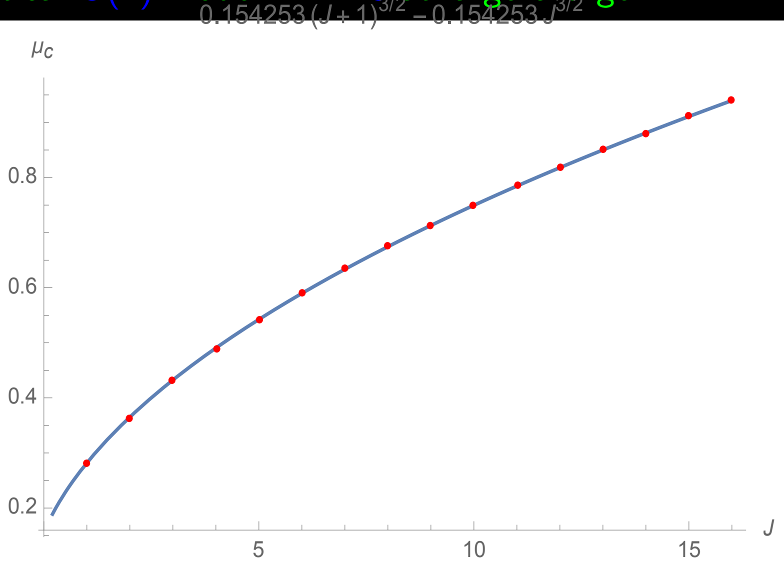

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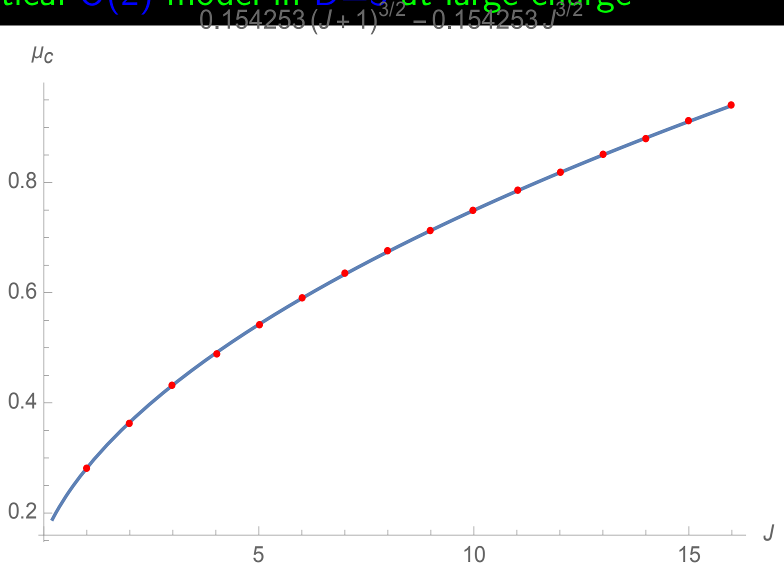

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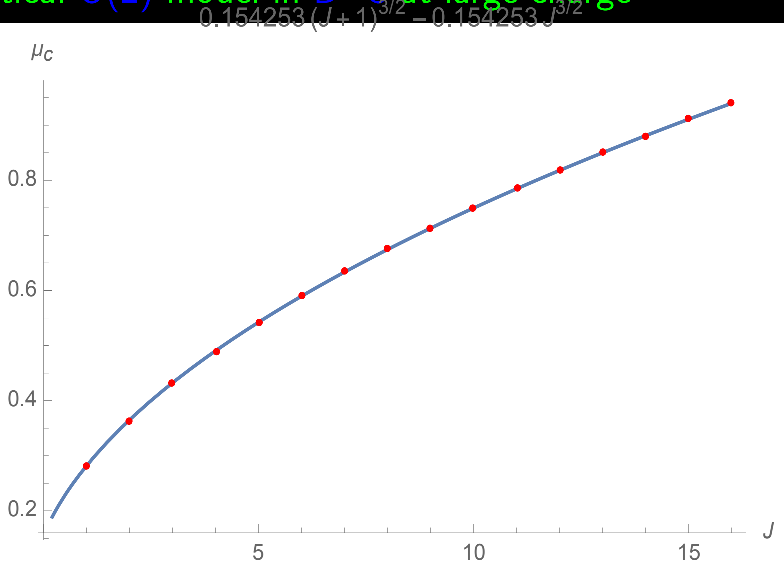

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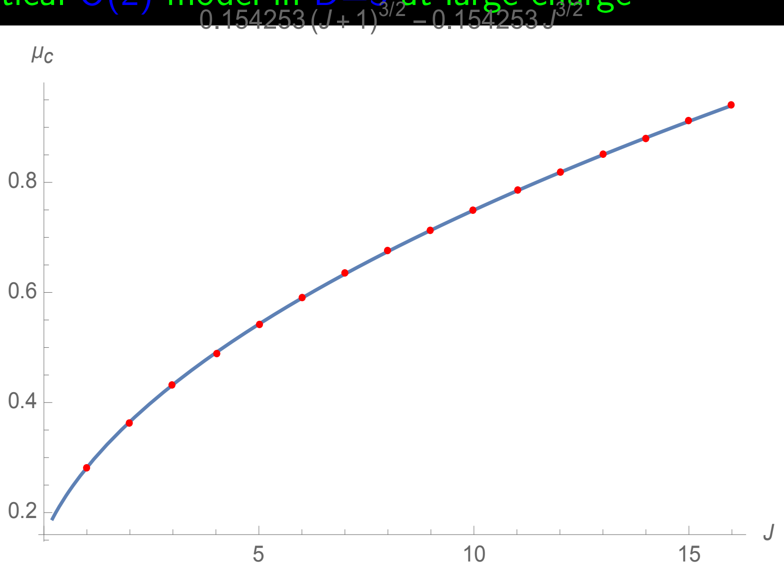

The value obtained by fitting the $J = 15$ point gives

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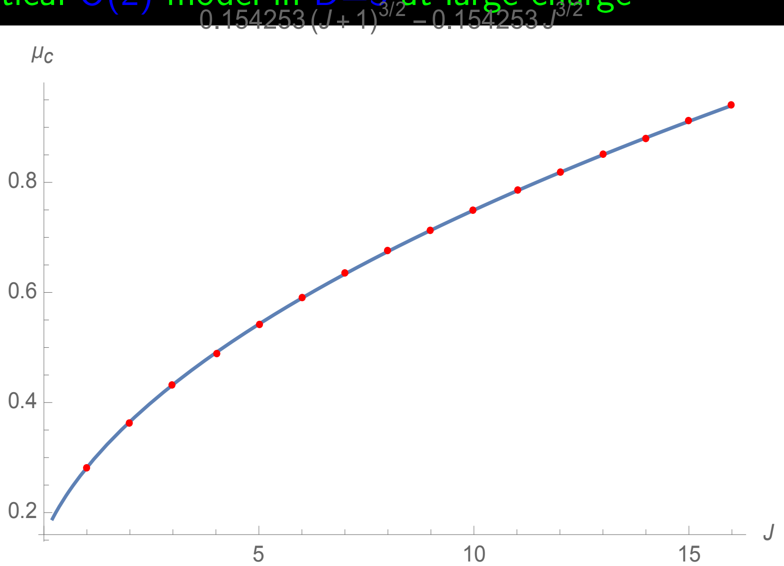

The value obtained by fitting the $J = 15$ point gives $E_J^{(0)} \sim 1.23402\, \ell^{-1} J^{\frac{3}{2}}$,

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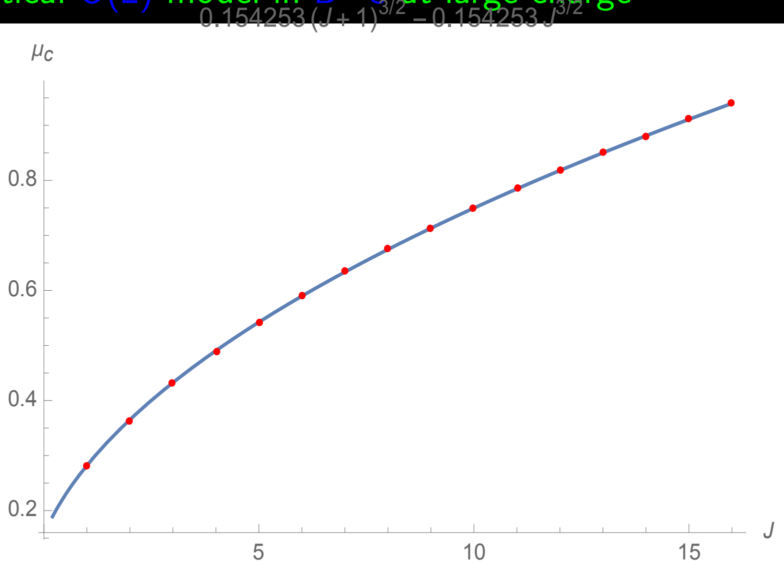

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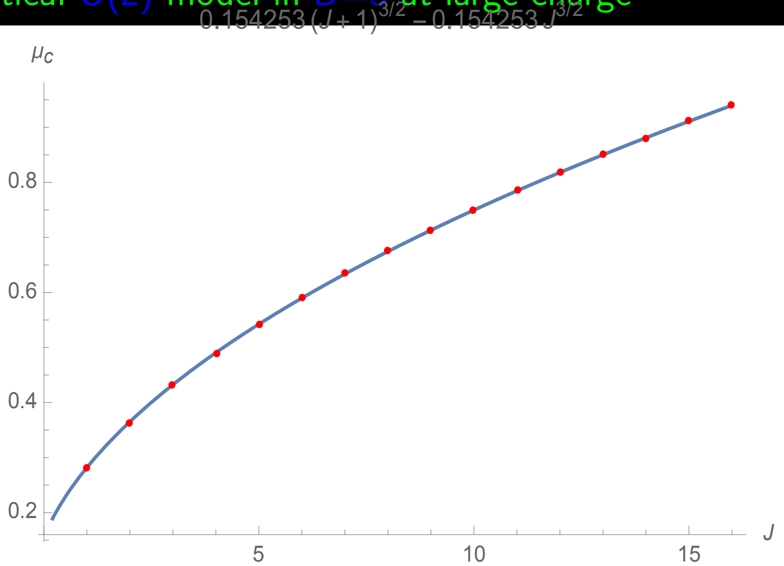

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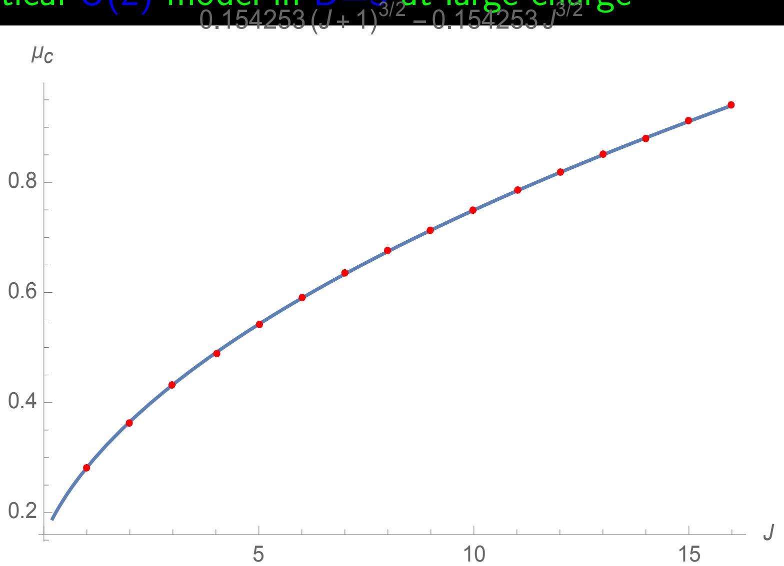

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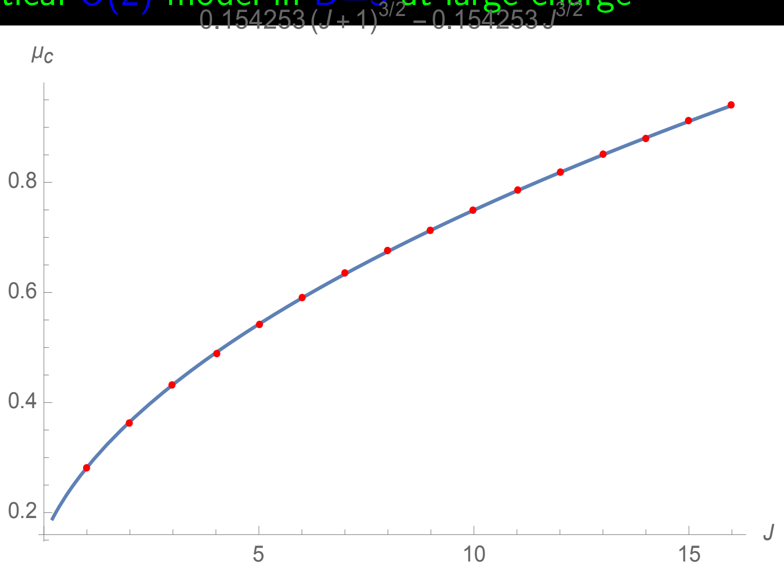

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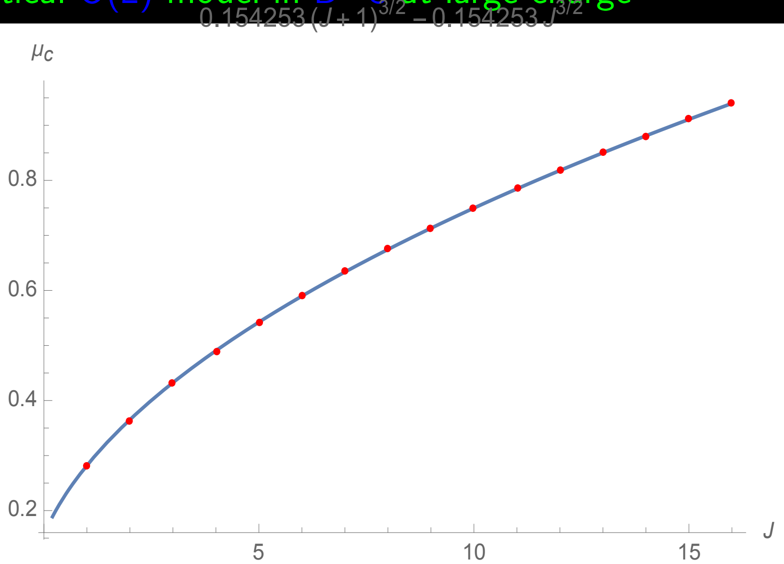

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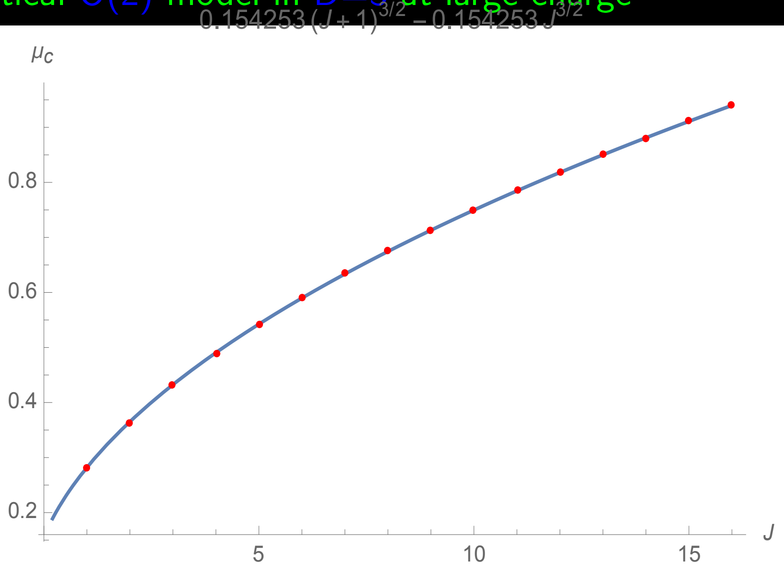

The value obtained by fitting the $J = 15$ point gives $E_J^{(0)} \sim 1.23402\, \ell^{-1} J^{\frac{3}{2}}$, where ℓ is the circumference of each cycle of the square torus.

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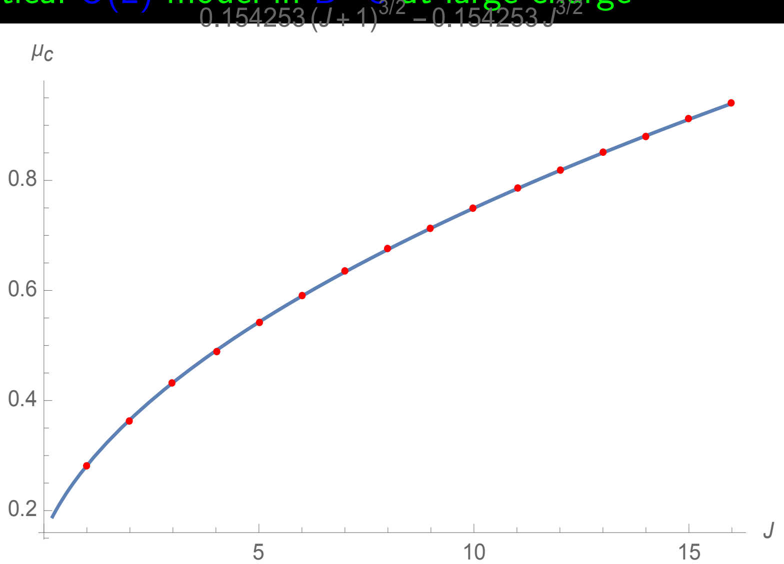

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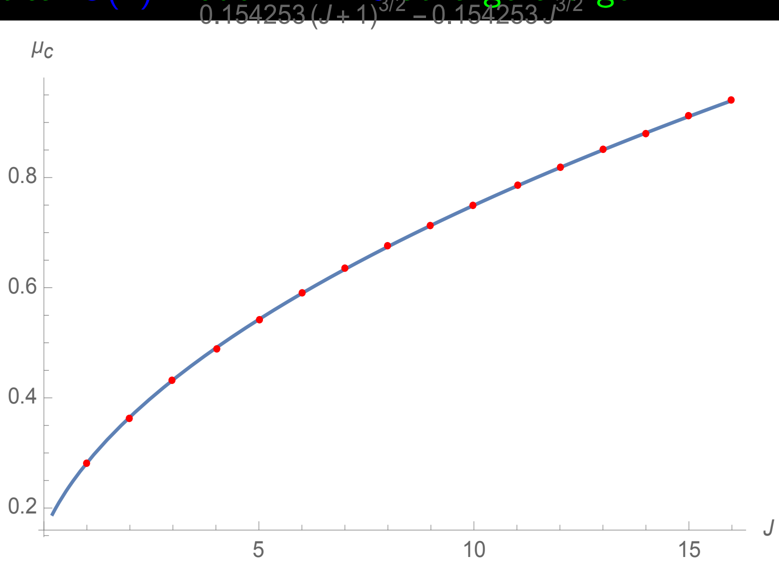

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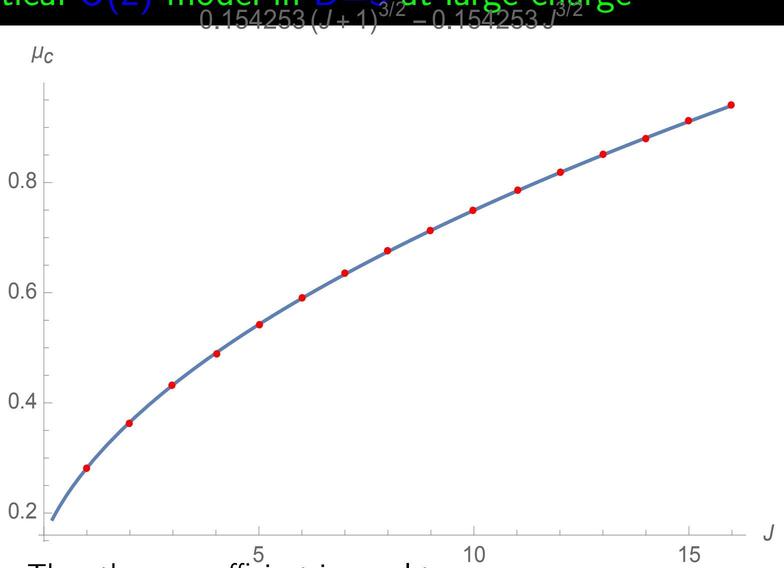

Then the $c_{\frac{3}{2}}$ coefficient is equal to

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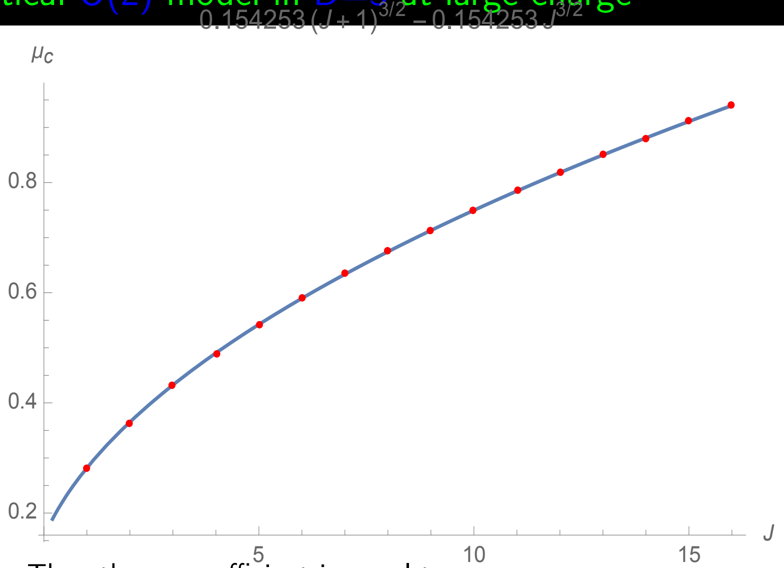

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$$c_{\frac{3}{2}} \equiv \left(\frac{\texttt{Area}}{4\pi}\right)^{\frac{1}{2}} \cdot \left(\text{coefficient of } J^{\frac{3}{2}} \text{ in } E_J\right) = \frac{1.23402}{\sqrt{4\pi}} = 0.348111 \ .$$

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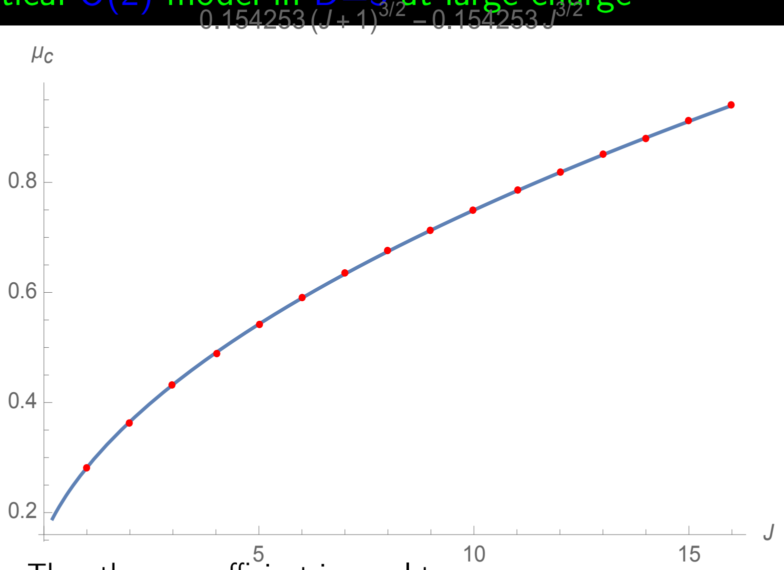

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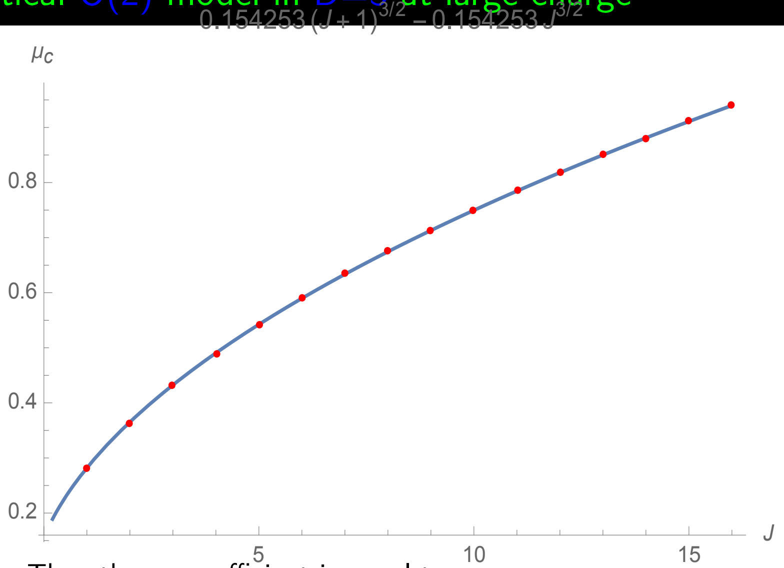

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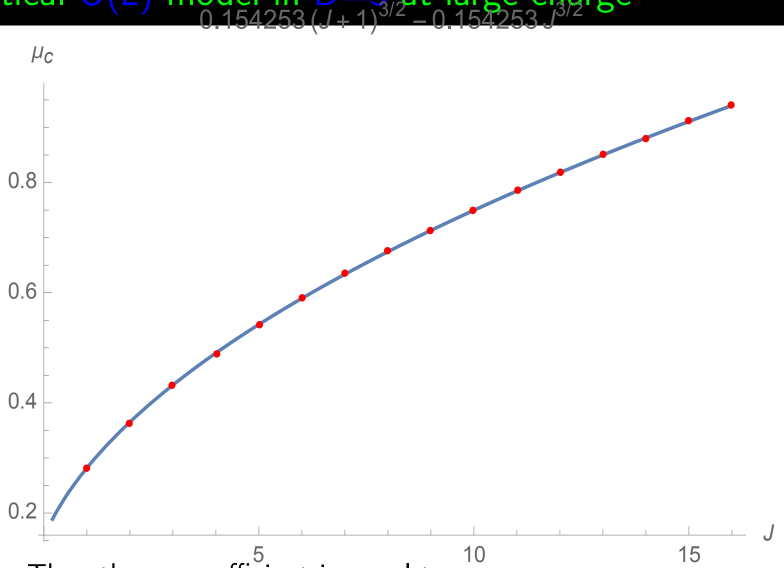

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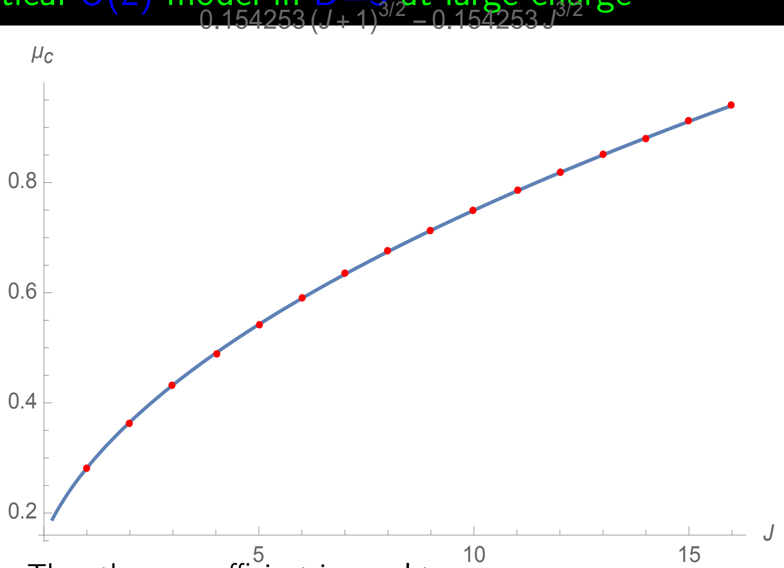

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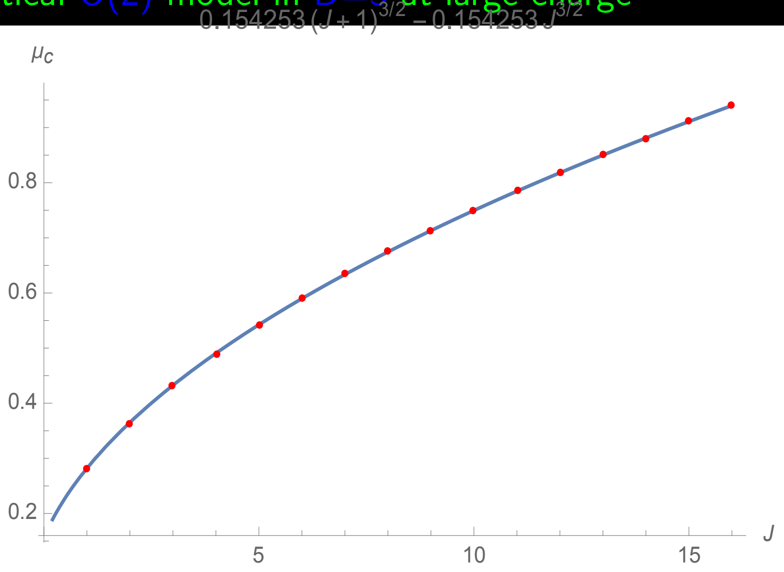

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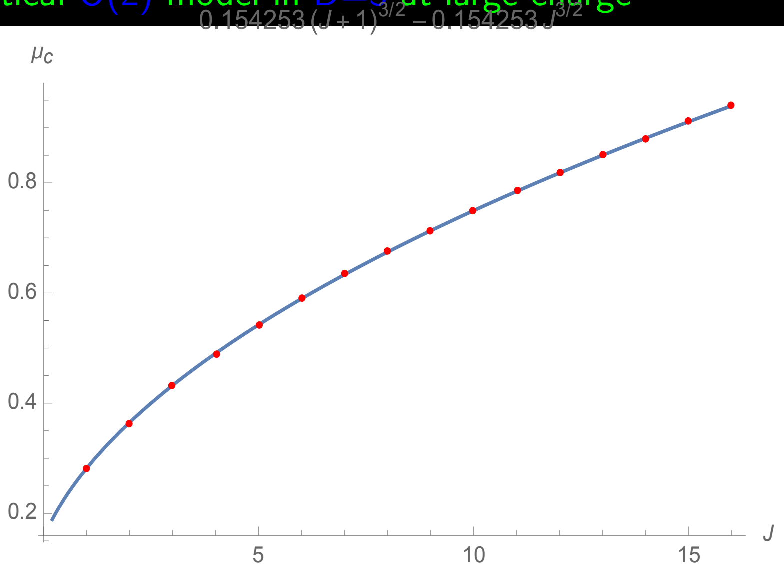

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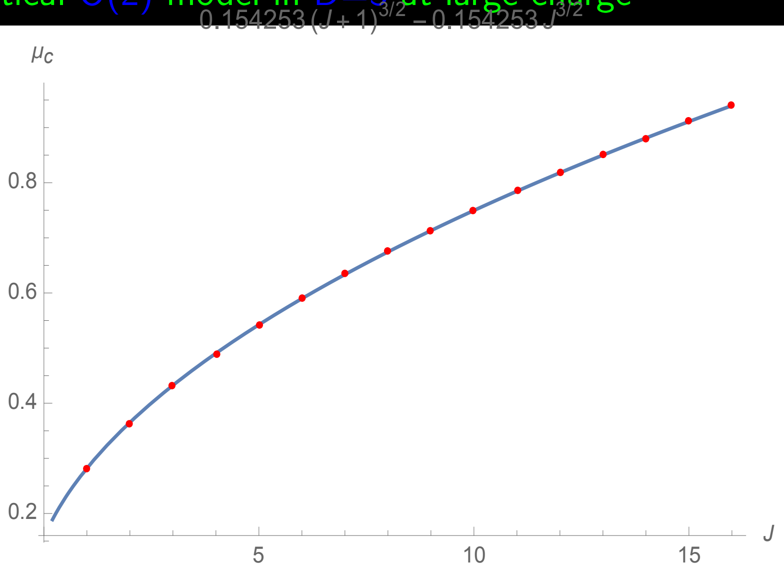

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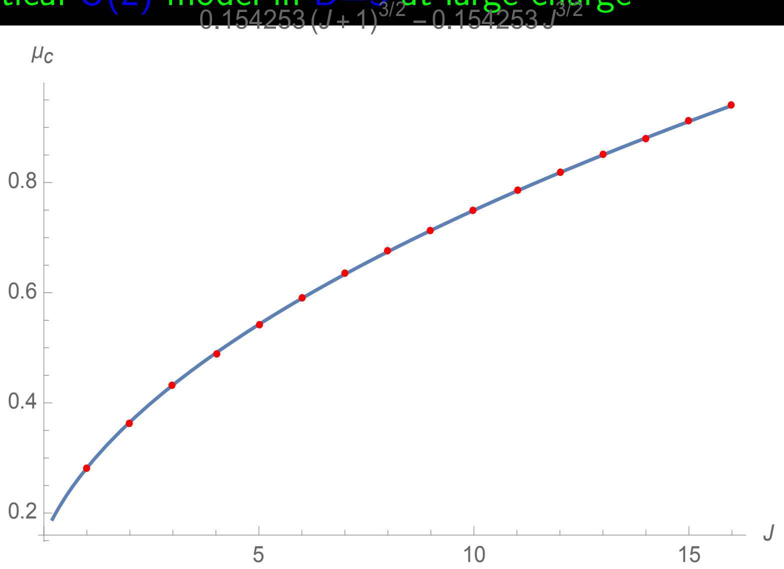

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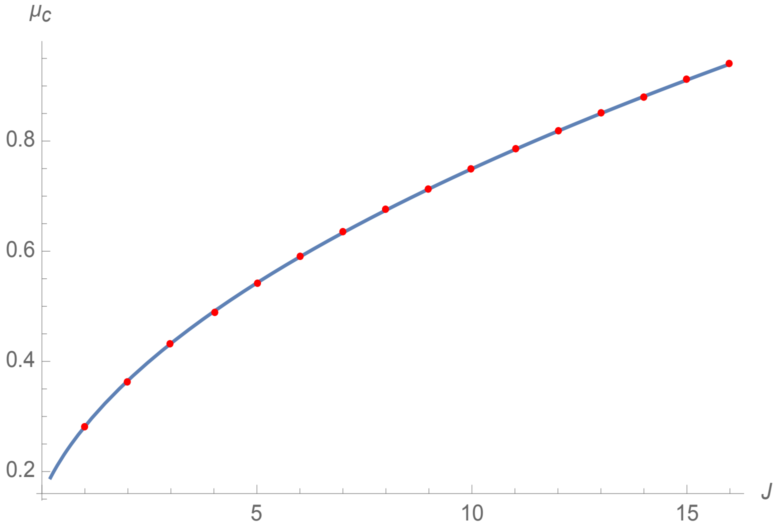

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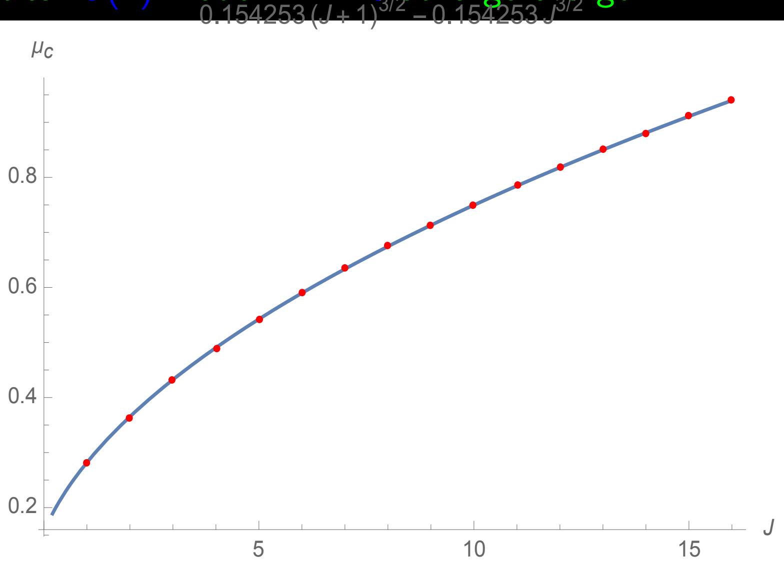

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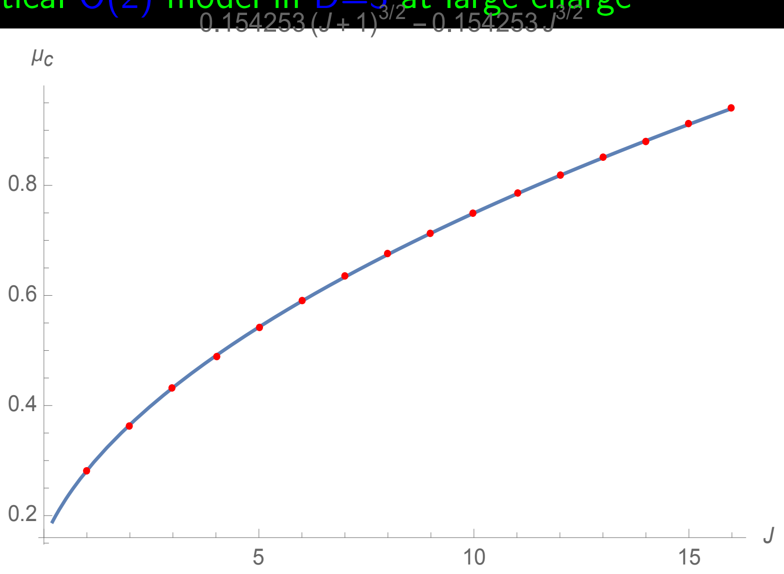

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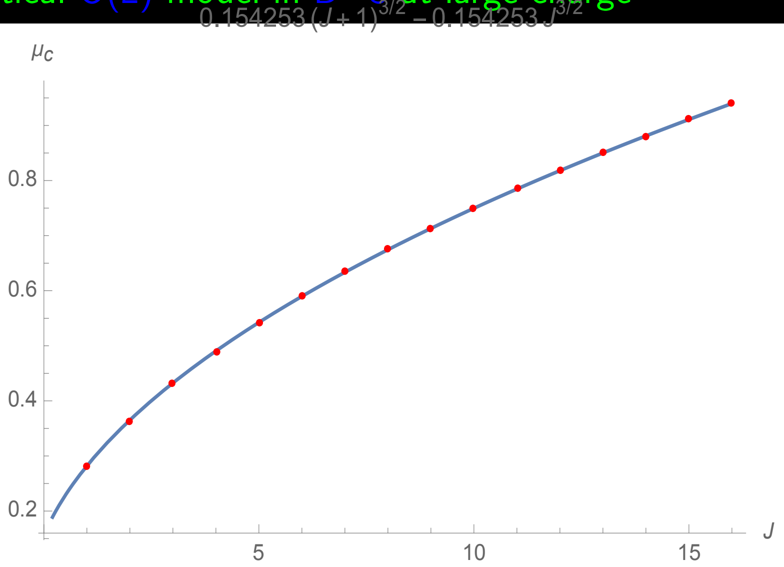

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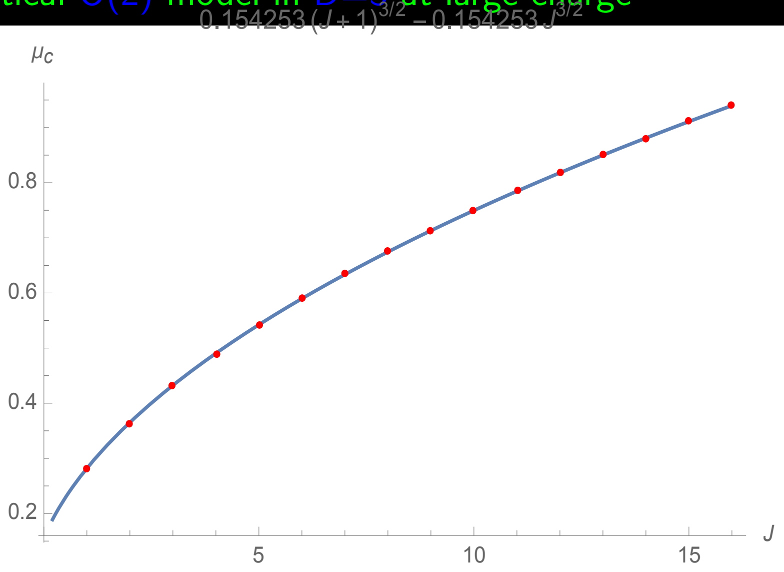

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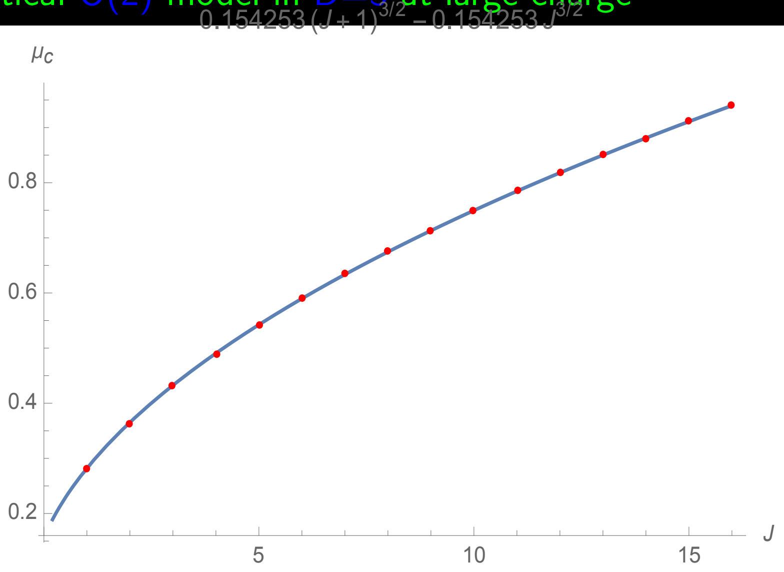

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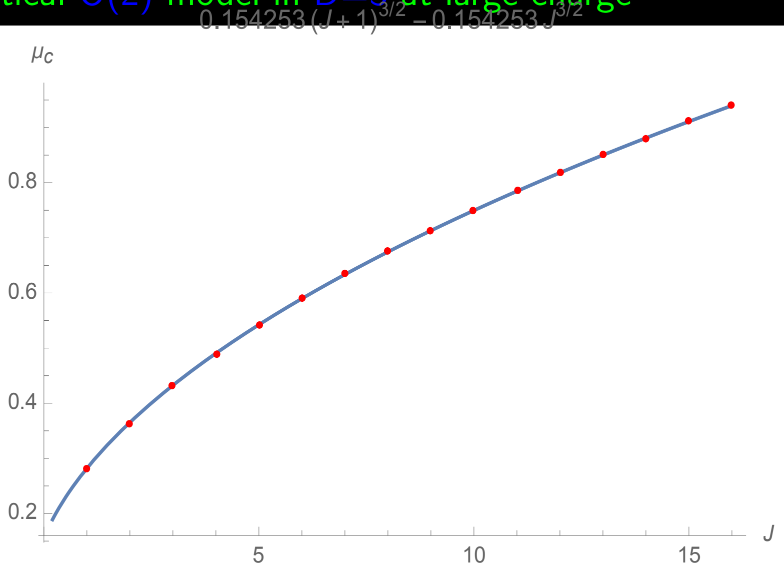

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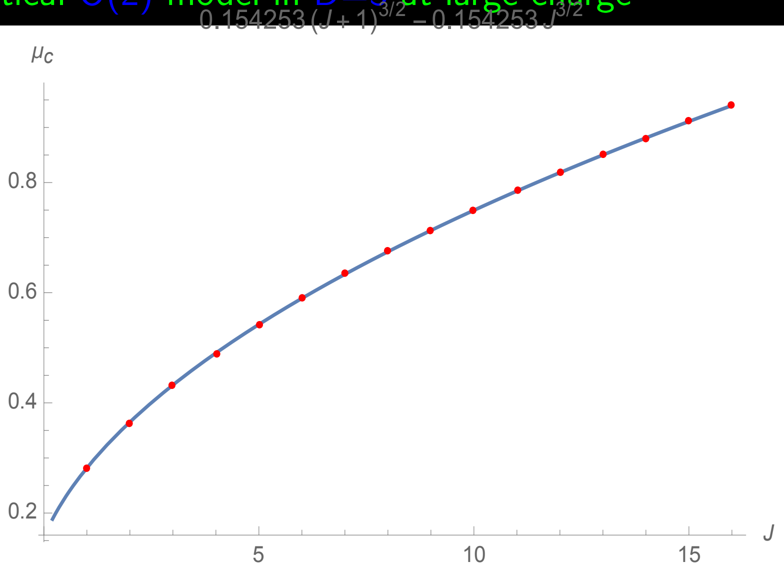

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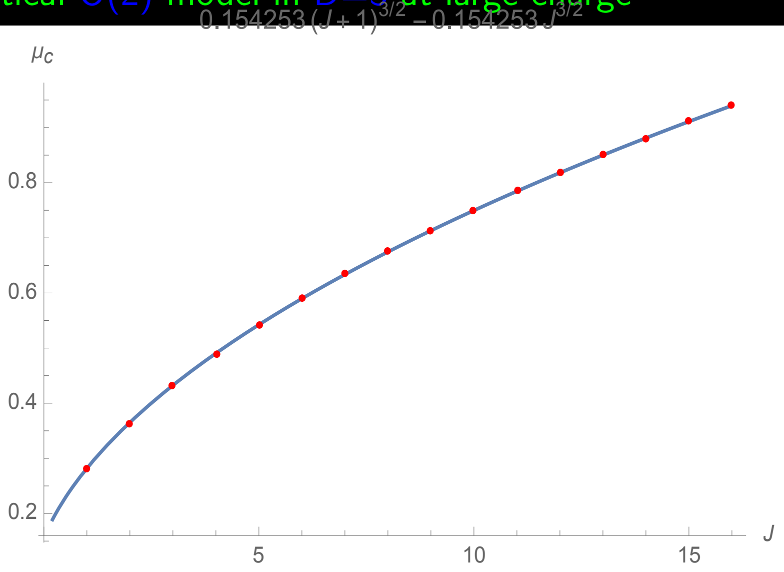

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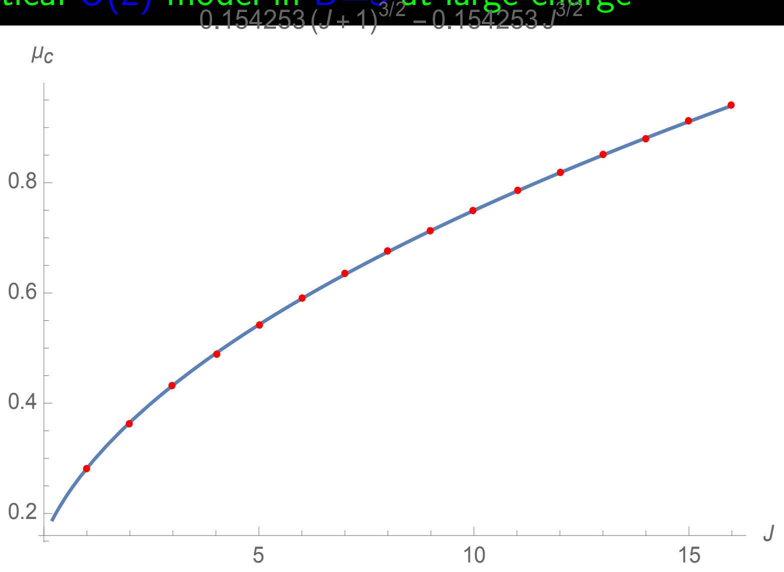

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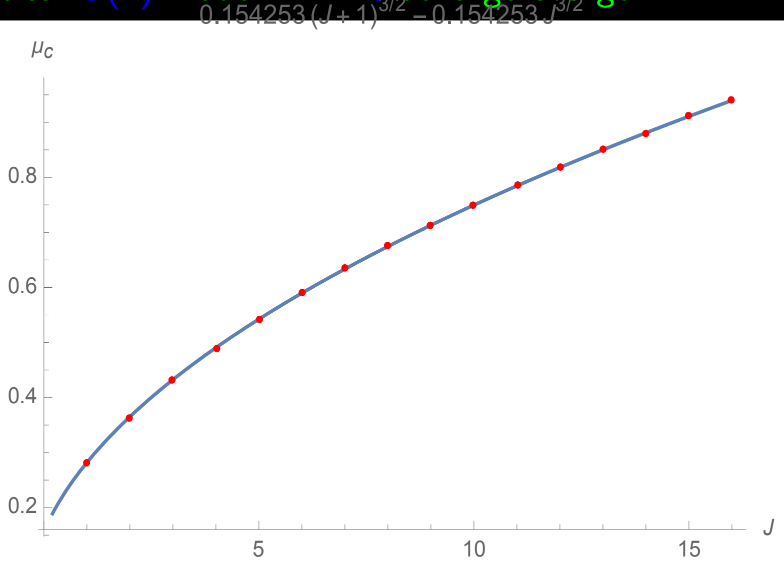

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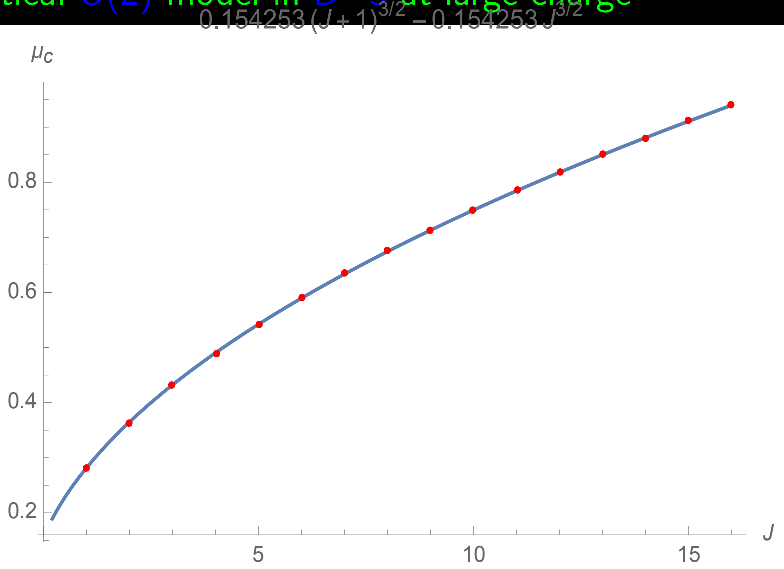

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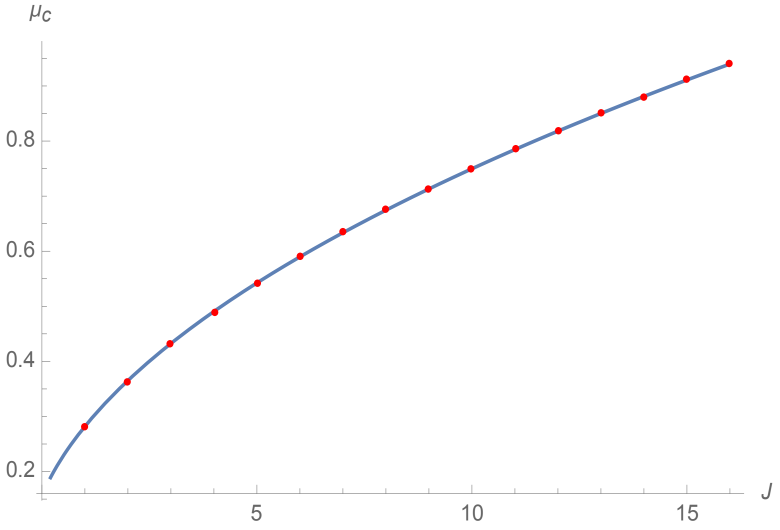

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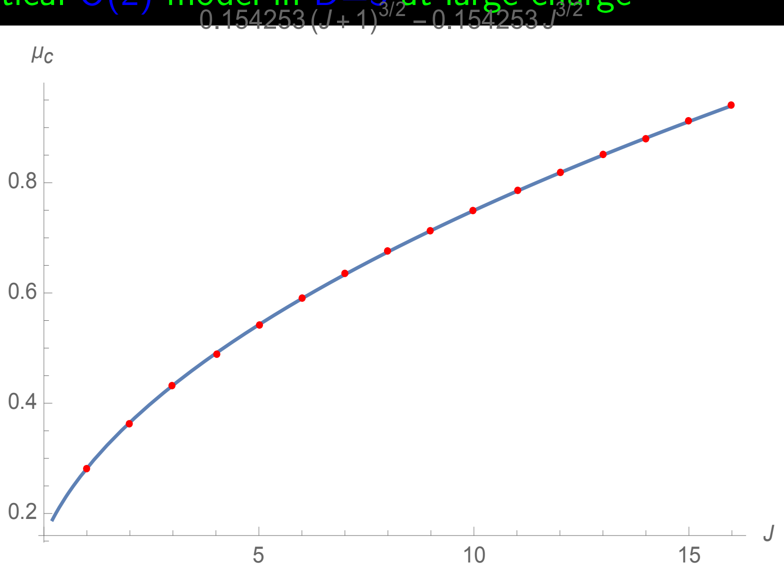

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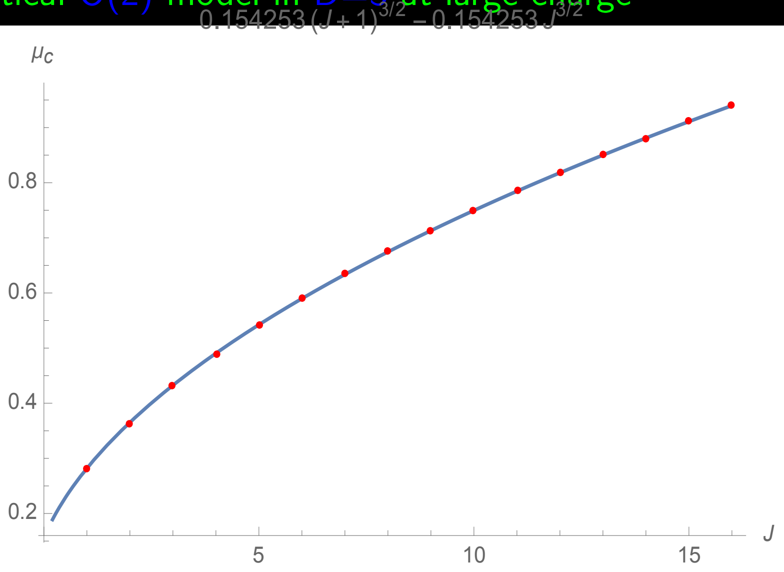

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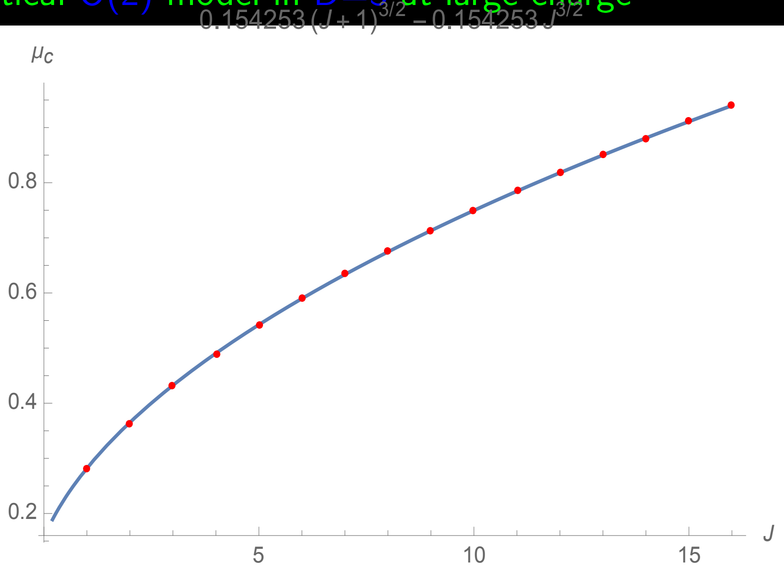

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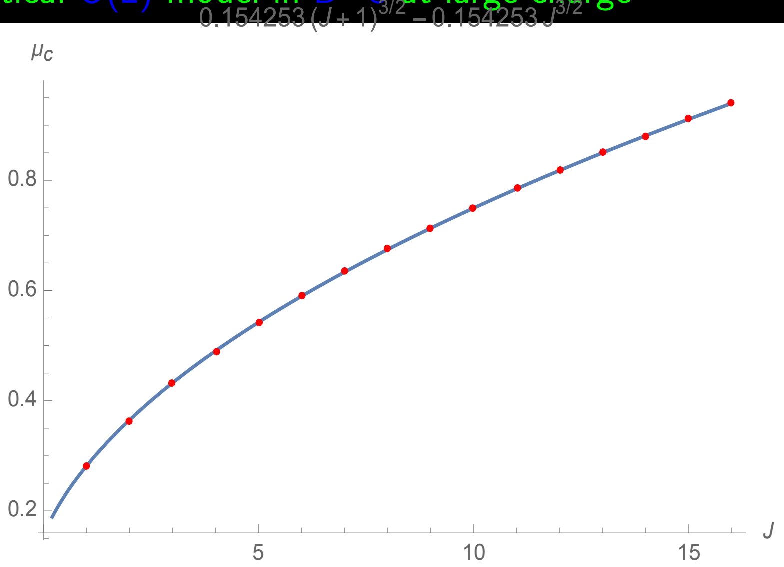

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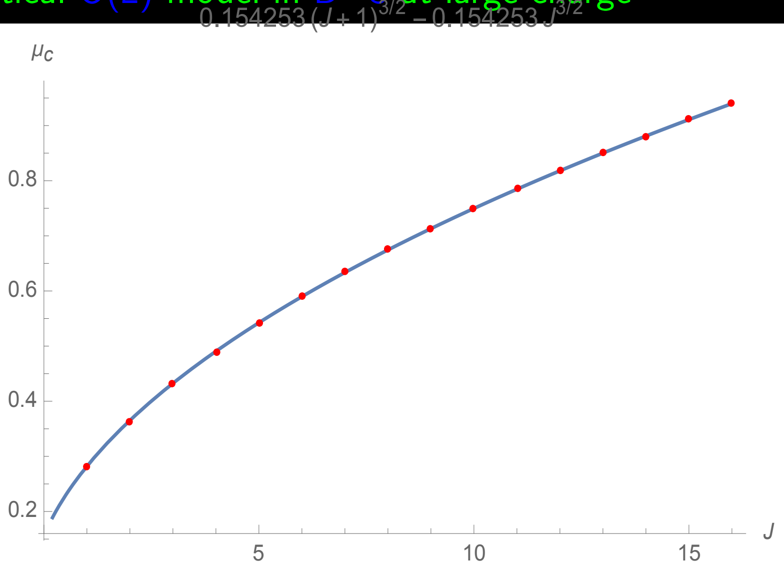

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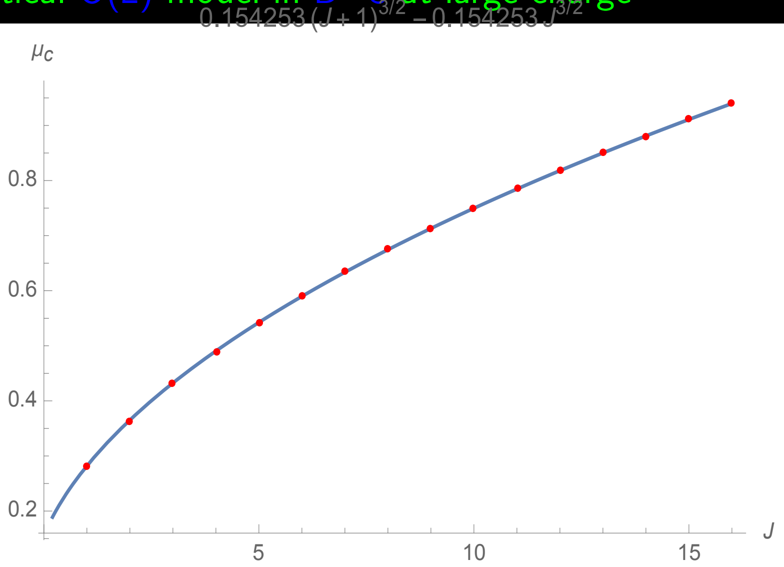

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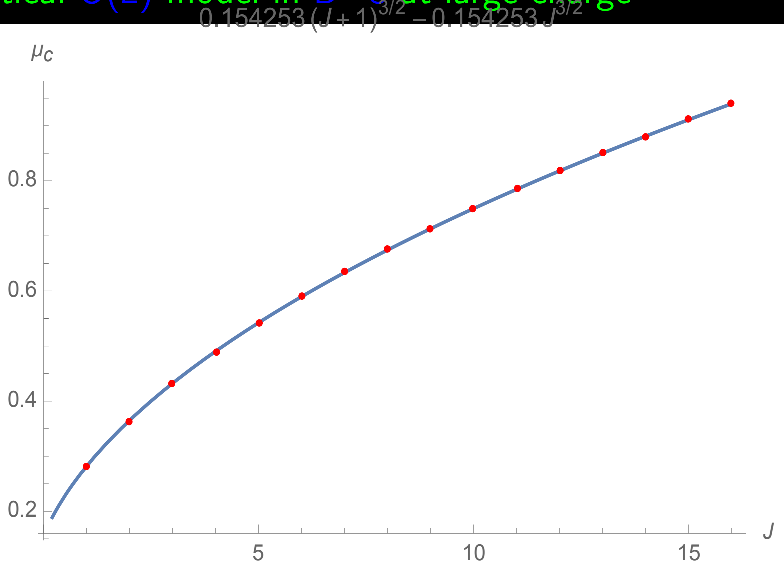

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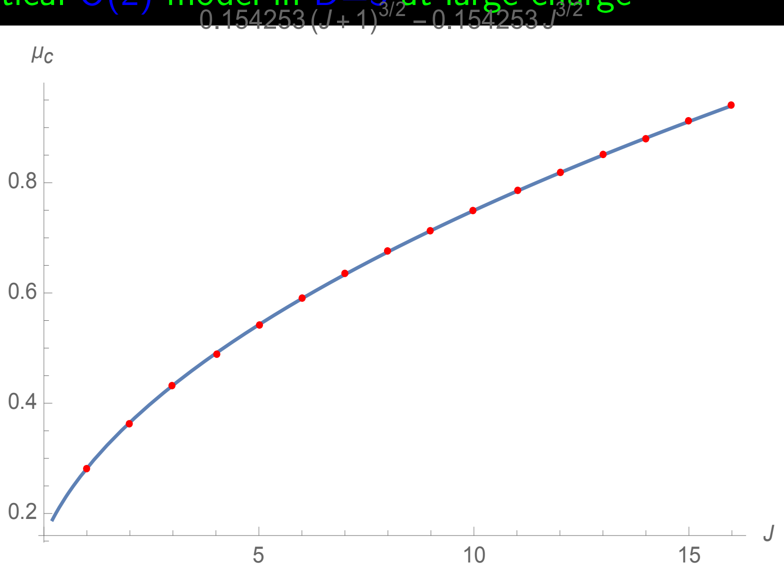

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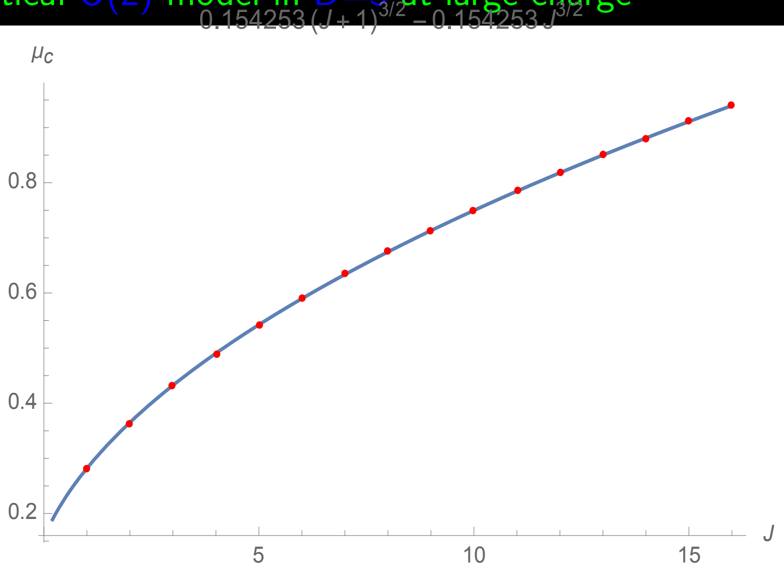

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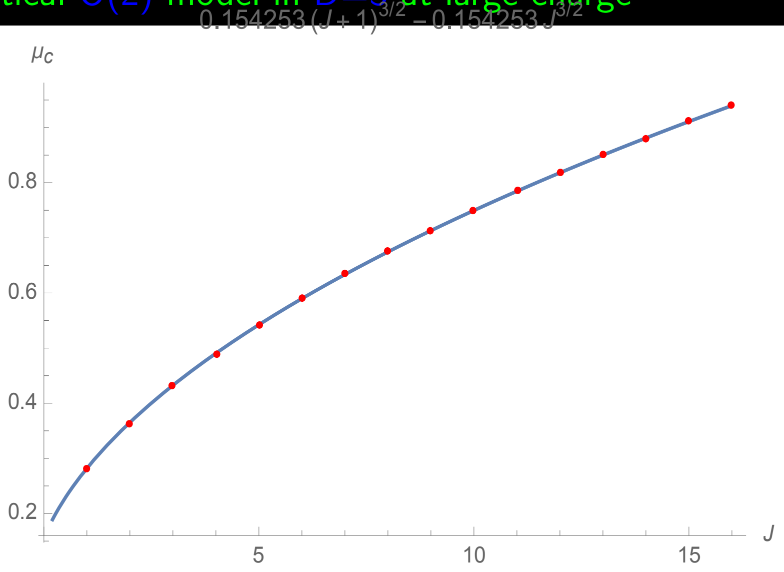

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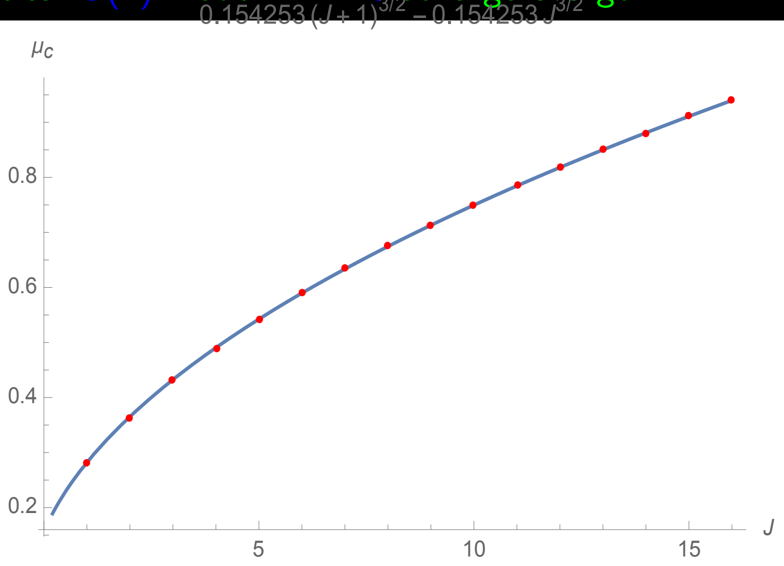

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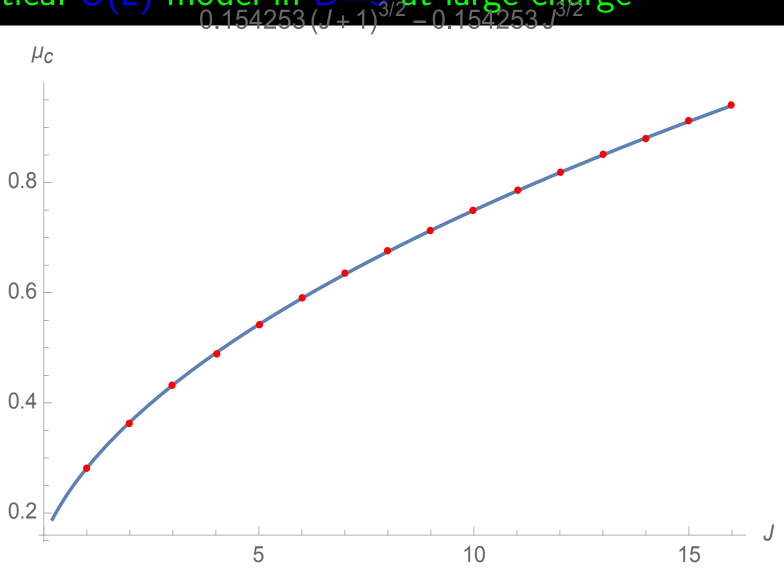

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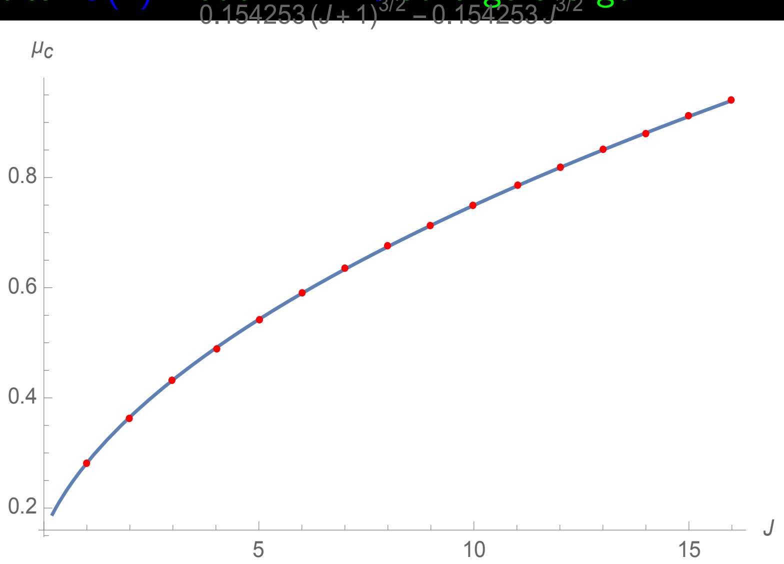

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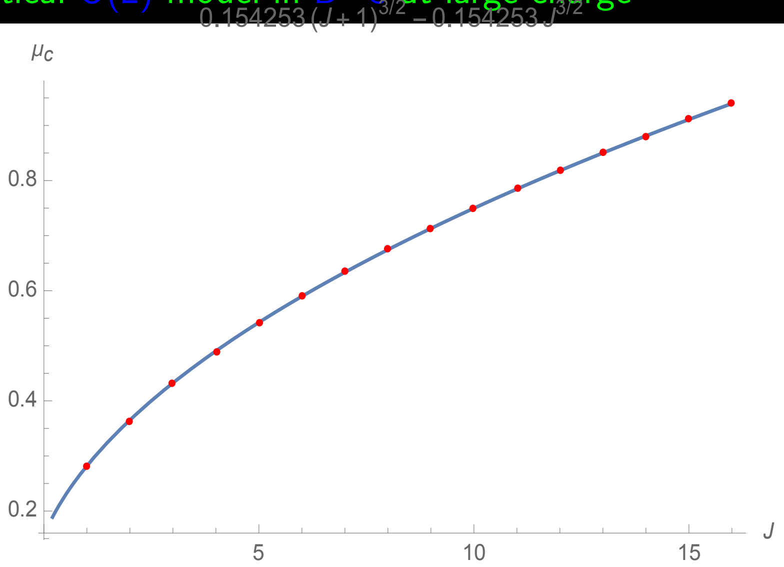

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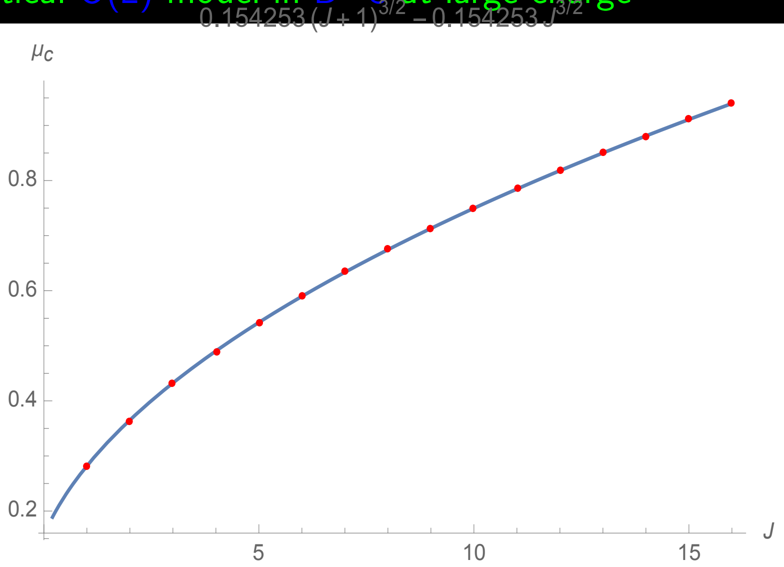

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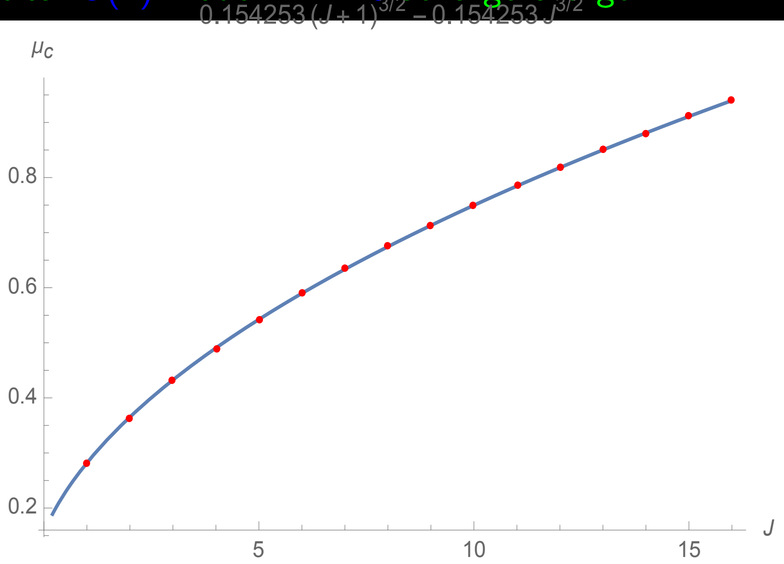

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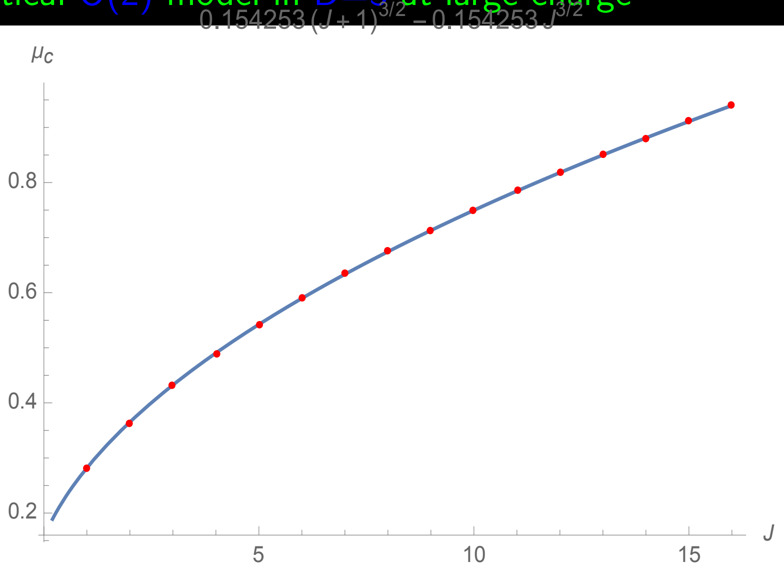

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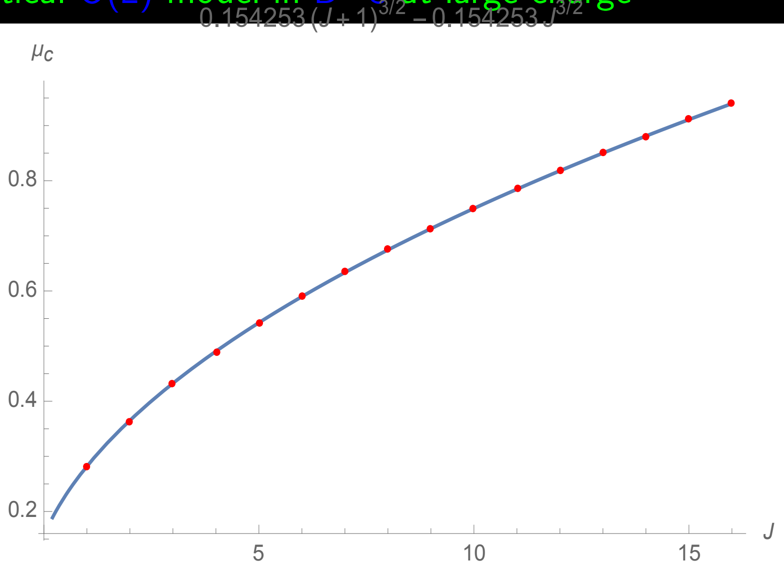

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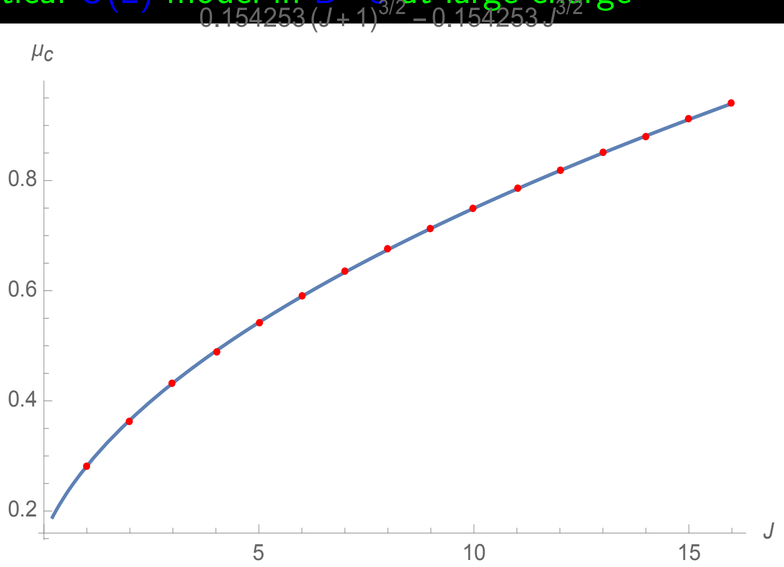

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Large charge with vs. without a vacuum manifold

- A theory with

Large charge with vs. without a vacuum manifold

- A theory with no vacuum manifold

Large charge with vs. without a vacuum manifold

- A theory with no vacuum manifold must necessarily have a

Large charge with vs. without a vacuum manifold

- A theory with no vacuum manifold must necessarily have a J-scaling

Large charge with vs. without a vacuum manifold

- A theory with no vacuum manifold must necessarily have a J-scaling for the

Large charge with vs. without a vacuum manifold

- A theory with no vacuum manifold must necessarily have a J-scaling for the operator dimension Δ_J

Large charge with vs. without a vacuum manifold

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Large charge with vs. without a vacuum manifold

- A theory with no vacuum manifold must necessarily have a J-scaling for the operator dimension Δ_J of its lowest primary

Large charge with vs. without a vacuum manifold

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Large charge with vs. without a vacuum manifold

- A theory with no vacuum manifold must necessarily have a J-scaling for the operator dimension Δ_J of its lowest primary of charge J

Large charge with vs. without a vacuum manifold

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- The only allowed scale invariant relationship is of the form $\mathcal{H} \propto \rho^{3/2}$.
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Large charge with vs. without a vacuum manifold

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Large charge with vs. without a vacuum manifold

- For theories with a non-nilpotent

Large charge with vs. without a vacuum manifold

- For theories with a non-nilpotent chiral ring

Large charge with vs. without a vacuum manifold

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Large charge with vs. without a vacuum manifold

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Large charge with vs. without a vacuum manifold

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Large charge with vs. without a vacuum manifold

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- Expectation values in free coherent states are in turn given by time-ordered perturbation theory in a vev, where the fluctuation propagator satisfies Feynman boundary conditions.
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Energy shift in large-J perturbation theory

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- This diagram does not vanish and it has no reason to vanish, since the third-lowest state lies in a long multiplet whose dimension is not constrained super-algebraically.
- Let us now be careful about the normalization and sign of this correction, relative to the normalization and sign of the FTP term in the action.
- Denote the normalization of the super-FTP term in the action as $\Delta\mathcal{L} \equiv \kappa_{\rm super-FTP}\, \mathcal{O}_{\rm super-FTP}$
  $\mathcal{O}_{\rm super-FTP} \equiv \int d^4\theta\, \mathcal{I}_{\rm super-FTP}$
  $\mathcal{I}_{\rm super-FTP} = \frac{|\partial\Phi|^2}{|\Phi|^4}$ where the superspace measure is normalized so that
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Energy shift in large-J perturbation theory

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$$S_{\rm CFT} = |\nabla\phi|^2 + (\text{fermions}) + S_{\rm FTP} + \text{higher order in } \frac{1}{J} ,$$

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Two- and three-point functions

- The first

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- The first correction

Two- and three-point functions

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Two- and three-point functions

- The first correction comes from inserting the FTP

Two- and three-point functions

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Two- and three-point functions

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Two- and three-point functions

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