Dear Dr Gu,  
  
Re: "Quantum cluster approach to the topological invariants in correlated Chern insulators" by Gu, Zhao-Long; Li, Kai; Li, Jian-Xin  
Article reference: NJP-110230  
  
We have now received the referee report(s) on your Paper, which is being considered by New Journal of Physics.  
  
The referee(s) have recommended that you make substantial changes to your article. The referee report(s) can be found below and/or attached to this message. You can also access the reports at your Author Centre, at <https://mc04.manuscriptcentral.com/njp>  
  
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REFEREE REPORT(S):  
Referee: 1  
  
COMMENTS TO THE AUTHOR(S)

The authors discuss an interacting version of the spinful Haldane model (aka Chern insulator) using quantum cluster approaches. Correlation physics in topological band insulators is an active and important field of modern condensed matter physics. Recently, the focus is also on interacting versions of Chern insulators. Thus, this paper addresses a timely issue.

In the current form, I do not recommend publication of this article, there are two major problems.  
(1) Quantum cluster approaches have been actively used in the past years to study correlated topological band insulators (in particular, on the honeycomb lattice); yet, the papers which are cited, are random papers, neither the first papers on this topic nor the most relevant ones – not even the available reviews are mentioned.  
(2) If the authors had invested the time to study the available literature they would be aware of the following problem: the symmetric six-site cluster (and presumably the same might be true for the two-site cluster?) on the honeycomb lattice produces an erroneous insulating phase ("MNI") for infinitesimal interaction strength.  
Back in 2012-2014 this was motivated by the "discovery" of an intermediate-U spin liquid phase on the honeycomb lattice, which was later falsified by numerically exact quantum Monte Carlo methods (Assaad and Herbut etc.). Yet there are several papers published where the presence of a putative spin liquid phase ("NMI") was found within quantum cluster approaches on the honeycomb lattice.  
The authors fail to address this at all - instead they cite Ref. [17] which is one of the few papers which claims that this (erroneous) NMI phase could be a spin liquid. I think it is very likely that the NMI phase found in the paper under consideration is connected to the erroneous NMI of Ref. [17]. Thus, it might be that the NMI phase is an artifact after all (disagreeing with the authors conclusion).

And here comes the most problematic part of the paper: the authors are only showing results for t'/t > 0.1, thus the region 0 < t'/t < 0.1 which would reveal whether or not the erroneous (previously mentioned) NMI phase is present here as well is not shown.

In the following I'm going to explain briefly why I believe the NMI phase is an artifact. Within real-space quantum cluster approaches, the hoppings within the cluster become renormalized in the presence of interactions. The hoppings between the clusters are, however, the bare hoppings. Even if they are treated variationally, they will be different from the hoppings on the cluster. Now the honeycomb lattice is known to be unstable towards on plaquette anisotropy, this has been discussed first in Laubach et al [Phys Rev B 90, 165136 (2014)], there might be also other papers. Consequently, for any finite interaction strength on the honeycomb lattice quantum cluster approaches will find a gapped phase. Even in the presence of a gapful term (such as the Haldane term) this phase is still present. I suspect that the NMI phase discussed in this paper is the very same phase (an artifact of the quantum cluster approach).

I would suggest that the authors show in their revised version of the manuscript how the phase diagram and the observables behave in the regime t'/t<0.1. That might clarify the situation.

Referee: 2  
  
COMMENTS TO THE AUTHOR(S)

In the manuscript entitled as “Quantum cluster approach to the topological invariants in correlated Chern insulators”, Z.L. Gu and his collaborators studied the half-filled Haldane Hubbard model with variational cluster approach at zero temperature. Their studies were conducted on two clusters with different geometries, i.e. one is the primitive cell of the honeycomb lattice; the other one is a unit cell with 6 correlated sites. The apparent discrepancy between the topological Hamiltonian approach and the edge states calculations were observed on the smaller cluster H2. But the bulk-boundary correspondence was restored in the 6-site cluster H6. Based on which the author concluded that, in nearly all cluster approaches, the choice of cluster matters and they have to respect the translational symmetry of the lattice as much as possible in the tiling procedure. Although this is somewhat a natural expectation, the author presented a careful study and serious calculations to verify it. In particular, the authors showed that the topological Hamiltonian still works in the correlated regime where the topological gap has been closed and reopened. The Hamiltonian can equivalently predict the topological phase transition as the edge state calculations did. The manuscript is nicely organized and the conclusion is consistent with the calculations. I can recommend it for publication on New Journal of Physics after minor corrections:  
  
1. It is not clear how the correlated edge states were calculated in Fig. 5. I guess the authors did not really calculate a ribbon with 15\*6 correlated sites but rather used the self-energy of the 6-site cluster to artificially build the ribbon. It should be made clearer how the authors did this calculation.   
  
2. Page 12, line 21, “spinless free” is confusing.

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