Referee report on "Dynamical localization and slow thermalization in a class of disorder-free periodically driven one-dimensional interacting systems"

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In the resubmission of their manuscript, the authors address the criticism concerning the stability of the claimed Hilbert space fragmentation in the thermodynamic limit by considering their model with a spatial period of two at lower frequencies. Their criterion for dynamical localization is $\mu = V = n\omega$ for $n \in 2\mathbb{Z} + 1$.

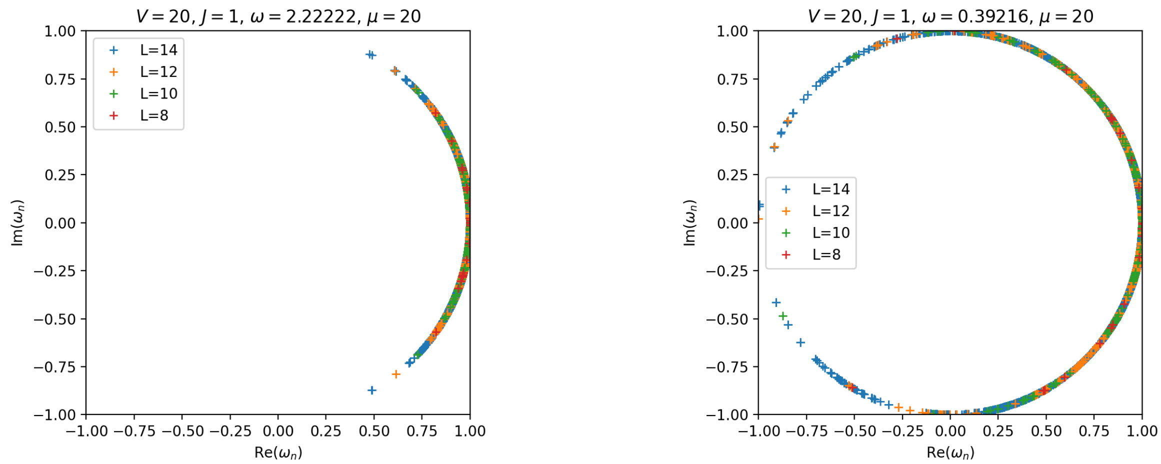

FIG. 1. Left: Spectrum of the Floquet operator of the period-2 model at the dynamical localization point with $n = 9$. Right: Spectrum of the Floquet operator of the period-2 model at the dynamical localization point with $n = 51$.

Unfortunately, I do not find the new analysis convincing to conclude that the phenomena are stable in the thermodynamic limit. The problem is, that the presented new data still shows no sign that the Floquet spectrum covers the unit circle and hence the possibility of many-body resonances is not yet explored. It is however clear that this regime must be reached at larger system sizes, since the many-body bandwidth grows with system size.

To understand the evolution of the spectrum with system size at low frequencies, I have plotted the spectrum of the Floquet operator of Eq. (4) at the dynamical localization point at $n = 9$ at half filling and compared it to $n = 51$ in Fig. 1. Even from the small system sizes I show here, it is clear that in both cases, the system is in a finite size, high frequency regime. Increasing the system size (here, probably a factor 10 in L is required) will eventually wrap the spectrum around the circle many times and create the possibilities for resonances, which may interfere with the discussed Hilbert space fragmentation.

This is a common fallacy in finite size numerics with large model parameters ($V, \mu = 20$, both of the order of the many-body bandwidth). In this "strong interaction regime" as the authors call it, it is essentially impossible to draw conclusions about the limit of $L \to \infty$ from small size data.

I therefore conclude that this paper is a comprehensive study of a class of Floquet models which exhibit interesting behavior at finite size, which is relevant for small scale experiments. It does however not provide sufficient evidence that the observed phenomena form a nonequilibrium phase, stable in the thermodynamic limit.

This paper does not fulfil any of the SciPost Physics "Expectations" in the acceptance criteria.

I hence recommend publication in SciPost Physics Core.