SciPost - Review for "HarmonicBalance.jl: A Julia suite for nonlinear dynamics using harmonic balance"

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1 Synopsis

The authors present an open-source software package, suitable for aiding the analysis of many non-linear driven dissipative systems. These systems often have harmonic time-dependent drives, and their steady-states can be found using the method of harmonic balance. This involves making the ansatz that the final solution includes only a finite set of harmonics with slowly varying amplitudes, obtaining a set of slowly varying amplitudes one can study more easily, since the time-scale of the dynamics is now massively increased.

Often, one is not interested in the dynamics of these equations, but rather the steady-state configurations and the different operation regimes of the system in question. Doing this requires an analysis of the fixed points of the harmonic equations, which in turn entails the solution of a system of non-linear equations. Here comes the main novelty of tool in question, which builds on another open-source software package - HomotopyContinuation.jl. This allows the authors, in many cases of interest to physics and engineering, to find the entire set of solutions for the harmonic equations in one go.

2   Report

First, I would like to commend the authors for presentation and clarity of the manuscript. The paper is extremely well-written and explains the concepts and their applications in a very concise and clear manner. The figures are clean and informative, and really aide the reading and understanding of the concepts in the paper. It is really a fantastic review of the material, and I am sure many people in the community of driven-systems would benefit from it.

As a tool, I find the package to be very useful and convenient. It provides a very useful and versatile analysis tool that would surely be useful to many people in the community.

Functionality wise, the package includes many useful, and very versatile tools. One can scan easily scan any pair of parameters to visualise the configuration state. However, the package still lacks some important tools, especially lacking is the identification of limit-cycles in addition to attractors and unstable point. This is a very central and very common state in many driven systems, and this functionality is severely missing from the package.

In terms of performance, I ran the software package on an M1 MacBook Air. For the Duffing oscillator problem presented in the paper, and for the same parameters and ranges, I've found the performance to be quite close to what's reported in the paper. It would be great, however, to include a performance comparison between HarmonicBalance.jl and other common tools.

Some quality of life suggestions -

- The plotting functions are very useful and convenient, but it would be nice to be able to have more customization options, or even better - have access to the data points directly.

- A more detailed progress indicator would be very useful, especially for longer calculations. Right now the only progress indicator is the one generated by HomotopyContinuation.jl.

With that said, and as the authors recognize - the tools it uses are published and known, and nothing in the package provides real novelty, even into the Julia framework. I do not want to downplay the importance and utility of the package as a tool, but it does not introduce any new capabilities, not generally, and not even specifically into Julia. None of the tools used in HarmonicBalance.jl are new - the harmonic equations are found straightforwardly using the Symbolic.jl package of Julia, the equations are solved and analyzed using the DifferentialEquations.jl package, and the steady-state configurations are found using HomotopyContinuation.jl package and the graphics are done using the standard graphics libraries of Julia. Generally, HarmonicBalance.jl does not provide any novel computational capabilities or methods that were not known or inaccessible before, rather its main contribution is packaging them all together in a very convenient form, both in terms of the software package and in the very clear explanations and examples given in the manuscript.

To summarize, while the scientific novelty of this manuscript is not high, a fact the authors are very clear and honest about, I believe its practical contribution is high. The software package gives just the right level of specification to make it easy to use, but keeps a level of abstraction to not become hindered when applied to other general problems of interest.

As a scientific paper, it is very well written, but its scientific novelty is quite low. I think it definitely deserves publication, but perhaps not in **SciPost Physics**. I would recommend publishing it as a review article on **SciPost Physics Lecture Notes**, or as an acommpanying paper for the package on **SciPost Physics Codebases**, rather than as a research article.