Review Petr Kabath Habilitation Thesis

Plagiarism

The Turnitin plagiarism report finds an overall match of 25% to the 10 works included in the habilitation thesis, with a maximum upper limit of only 2% for any given single work. It is clear to me that the work represents an original piece, with negligible overlap from the author's own work, and some standard phrases used in the field being highlighted by the plagiarism algorithm.

"It would be desirable to express in your review your opinion towards significance of the results for the development of the science and the originality, topicality of the thesis, and methodology used for solution of the given problems."

Main Report

The thesis highlights the work that has been done related to ground-based follow-up of transiting planet candidates from space missions, particularly using the OES spectrograph at the Perek-2m telescope in the Czech Republic.

To begin, many grammar errors are found throughout the thesis, showing that the document could have used a more deep and thorough English editing, particularly since a few areas appears to be rather rushed.

The introduction presents a very rapid overview of the history of exoplanet discovery, capturing most of the important milestones that have lead us to where we are now. However, it is very 'European' orientated, missing a number of key advancements made beyond the Geneva group, such as reaching 3m/s RV precision (Butler et al. 1996).

The paper Kabath et al. (2020) highlights well the capabilities of the OES instrument to discriminate between binary and exoplanet hosting stars from large-scale transit surveys. The experiments were clearly described, the RV precision highlighted, and the possibilities from the spectrograph and its impact on exoplanetary science was logically explained. One criticism here would be a lack of explanation of future upgrades to the OES, and how these would impact the RV precision of the instrument, and hence its usefulness for TESS and PLATO follow-up.

Whilst it is clear that small telescopes can play an important role in the follow-up vetting and characterisation of exoplanet candidates from wide-field transit surveys, the arguments presented in Section 2.1 for the photometric follow-up are weak. This part of the thesis could gain from a more detailed explanation of the current small photometric telescope capabilities, their advantages over their larger cousins, and indeed their weaknesses.

The Fruth et al. (2012) paper describing the BEST II photometric campaign to analyse the Corot fields represents a very nice example of how small telescopes can contribute to exoplanet follow-up, stellar characterisation, and stellar phenomena search. By implementing an instrument specific statistical approach to detrend photometric data, a search for variable stars that provided a two-fold improvement in the detection rate was made. The method allowed a better rejection of aliases and potential false positives, opening up further avenues of research for this instrument.

In Section 2.3, the rejection of false positives paragraph should also include the cleaning of possible eclipsing binaries, since the spectra can rule out many high mass-ratio scenarios by searching for the spectral signal of a secondary in the data. In addition, rapid rotation can also be ruled out, due to quick checks of the spectral line widths, which can further inform the follow-up efforts with larger telescopes, since rapid rotators may preclude the detection of small planets for example.

The Kabath et al. (2022) work presents highly important discoveries of gas giant planets made using the OES, in combination with two other instruments mounted on small telescopes. This is another clear example of the contribution that can be made with 2m class telescopes, once the appropriate framework for planet follow-up and measurements of precision RVs are put in place. These planets represent a couple of interesting examples, particularly the fact that TOI-2046b is a young and inflated planet. Young systems are highly sought after in order to develop our understanding of planet evolution, and therefore confirming an example of such a planet with the OES represents an excellent reward for the effort put into developing the system.

Section 2.4 could have been more extensive, especially within the scope of comparison between PLATOSpec and the OES. A mention is made to the increased efficiency of PLATOSpec, however a clearer outline of how PLATOSpec will deliver RVs that are nearly 20x more precise than OES is warranted. Is it simply the inclusion of the iodine cell? If so, this will cause ~50% of the signal to be lost, meaning the increased efficiency plus of PLATOSpec is not likely to be so much. A clearer explanation would have been helpful here.

In Section 3.1, there is a lack of information on the observational stressors for such a campaign to study the atmospheres of giant planets. What signal-to-noise ratios are necessary for example, which feeds directly into how feasible such a project is? What type of instrumental stability is required, fibres for example?

The entire section 3 seems rather rushed compared to the other sections, containing numerous errors in grammar and even the names of well-known planets and their stars.

The paper Kabath et al. (2019), being the first work to attempt to detect chemistry in an exoplanetary atmosphere with such small telescopes, represents an important work in the field, as it was able to demonstrate that such measurements are possible. The work also setup a framework for how observers can perform such campaigns, developments that can aid current and future observers with their studies of TESS and PLATO transiting systems. Follow-up works that were born from this study would have solidified the usefulness of this work, whilst taking advantage of the suggestions here, but possibly the pandemic stalled ay future plans. In any case, this was a bold and challenging effort that produced very useful results for the exoplanet community.

The paper by Sabotta et al. (2019) showcases a nice niche for small 2m class telescopes equipped with precision RV spectrographs. Not only can these instruments provide support to photometric surveys of bright stars, but they can also provide fundamental science results, like those shown in this paper.

Caceres et al. (2014) again highlighted the potential for mid-sized telescopes and how they can contribute to the studies of exoplanet atmospheres, given appropriately selected targets. Using instruments on mid-sized telescopes like SOAR, they were able to obtain enough precision to rule out certain proposed atmospheric constituents for the super-Earth GJ1214b, adding further statistical weight to the reality of the planet hosting an atmosphere of high mean molecular weight. Although challenging, these results again show the potential for large scale projects on smaller telescopes to study the atmospheres of exoplanets. Although we may think the sample size is limited to perform such studies, space-based transit surveys are providing new detections every month, with many more candidates awaiting confirmation.

The Zak et al. (2019) paper presents an interesting case of how archival data can be used to perform transmission spectroscopy measurements of sufficiently bright transit planet host stars. Two detections of sodium were made in the atmospheres of WASP-76b and WASP-127b, representing a new discovery and confirmation of a previous detection of this element in the planet's atmosphere. Although not ground-braking, these results continue to add to the large database of planets with detected chemical elements in their atmospheres, which are valuable points to help us understand better the global population of giant planets and their atmospheres. The niche in this work was that each of planets are inflated, a sub-set of the hot Jupiter population, and therefore sodium detections may point towards a marker that can be studied in greater detail in the future to better understand the inflation mechanism.

Overall Conclusions

I conclusion, it is clear that Dr. Kabath has focused firmly on exploiting the opportunities offered by smaller telescopes in the search and characterisation of exoplanets, particularly the fact that large chunks of time can be acquired more easily on these telescopes that their larger cousins. He has worked to develop instruments and observational techniques for small telescopes, has observed in both spectroscopic and photometric modes to exploit these opportunities, and has made significant scientific advances in the field. In addition, he is leading a new instrument called PLATOSpec, whose goal is to exploit the plethora of planet candidates orbiting relatively bright stars that the PLATO spacecraft should give rise too. Therefore, Dr. Kabath should be well positioned to continue and expand on the research lines he has been working towards over the past 10 years or more.

Coming to Dr. Kabath's CV, it is clearly shown that he is leading an exoplanet group in the Czech Republic, which encompasses being on the science committee of PLATO and the PI of the PLATOSpec instrument. These show he has the leadership skills necessary to expand on his current position. He has also been successful at winning various funding schemes to cover his research costs and instrument development, particularly related to PLATOSpec. He shows a H-index of 21 with 78 refereed papers and 1782 citations at the time of writing his CV, (a quick check finds a current H-index of 22, with 81 papers and 1903 citations). For the established time of research his H-index may appear rather on the low-side, however by focussing on small telescope research and instrument development, this could go some way to explaining these numbers. He is also shown to regularly give talks at international conferences, meaning he is connected and participates in important community activities, particularly connecting with international partners and showcasing his research.

Dr. Kabath has successfully supervised a PhD throughout the full term, with the student moving on to a successful postdoctoral position, showing he understands how to develop a project from beginning to end. Although the long-term prospects for his student cannot be measured at the time being, he has taken a position at the Center for Astrophysics at Harvard University, highlighting the potential possibilities that Dr. Kabath's group can offer students. He also has a further three doctoral students working on research projects, along with a Master's student, whilst two other successfully defended Master's students have passed under his supervision. Finally, he has been lecturing on exoplanets at the MFF UK since 2020, showing he can maintain a successful teaching commitment also.

In summary, I believe that Dr. Kabath has fulfilled the requirements to obtain the position of Professor. He has been able to maintain a clear research path spanning over a decade, he has published valuable scientific works that have branched into different areas from RV planet detection to atmospheric characterisation, he is part of large international collaborations, and is currently developing an instrument to help maximise the science from one of the large next generation observatories for exoplanet science, PLATO. Dr. Kabath has shown he can successfully supervise students throughout doctoral and master graduate programs, all the while performing administrative and teaching duties at the university.