

Habilitation thesis reviewer's report

Masaryk University	
Faculty	Faculty of Science
Field of study	Theoretical Physics and Astrophysics
Applicant	<i>Norbert Werner, PhD</i>
Affiliation	Stanford University
Habilitation thesis (title)	<i>From supermassive black holes to the large-scale structure of the Universe.</i>
Reviewer	Prof. Dr. Marcus Brüggen
Affiliation	University of Hamburg

Reviewer's report (extent of text up to the reviewer)

With his thesis *From supermassive black holes to the large-scale structure of the Universe* Dr. Norbert Werner has presented an authoritative and highly impressive piece of work that reflects his illustrious career as a young scientist. The work deals with the formation of structure in the Universe, in particular that of ordinary (called "baryonic" by astronomers) matter. This is a highly topical research area and Dr. Werner has emerged as one of the leading figures in this field. The thesis mainly builds on 10 peer-reviewed publications by Dr. Werner, 9 of which as first author and all with high impact (including in journals Nature and Science). His work has high numbers of citations and is discussed at the main conferences in this field.

In chapters 2 and 3 (based on Werner et al. 2010, 2011) ground-breaking observational work on the effect of active galactic nuclei on the gas in galaxy clusters is presented.

In chapter 5, Dr. Werner and collaborators use resonance scattering of X-ray spectral lines to measure AGN induced turbulence in the hot ISM of giant elliptical galaxies (Werner et al. 2009).

In chapter 4, the discovery of a very fundamental relation in the gas profiles in elliptical galaxies is described (Werner et al. 2012).

In chapters 6 and 7, Dr. Werner and collaborators use CHANDRA X-ray observations in combination with numerical simulations to explore the hydrodynamics and the microphysical plasma properties of the gas in galaxy clusters (Werner et al. 2016a,b).

It is shown in chapter 8 (Werner et al. 2013a) that the cold gas observed in giant ellipticals, here at the example of the galaxy at the core of the Virgo cluster, is produced mainly by cooling from the hot gas phase.

Chapter 9 (Werner et al. 2014) describes the discovery of large reservoirs of cold gas in nearby giant elliptical galaxies.

Finally, the work with the highest impact is presented in chapter 10, based on the Nature and Science papers Werner et al. (2013b) and Simionescu et al. (2013). These papers are the first studies of metallicity out to very large distances from the cluster centre. The data pose serious questions to the metal enrichment history of the Universe and the nature of the gas. This is pioneering work of the highest calibre.

Reviewer's questions for the habilitation thesis defence (number of questions up to the reviewer) ...

Will the new Russian-German X-ray telescope eRosita be useful for studies of AGN feedback?

Conclusion

The habilitation thesis submitted by Dr Norbert Werner entitled "From supermassive black holes to the large-scale structure of the Universe" *meets* the requirements applicable to habilitation theses in the field of astrophysics.

25.2016