Sebastiaan L. Zoutendijk

Title

Constraining dark matter with ultra-faint dwarf galaxies

Abstract

Despite the long history of dark matter, its nature is still unknown.
Cold dark matter (CDM) remains the generally accepted working
hypothesis. Apparent shortcomings in the ability of CDM to explain
various observations have been noted and have led to the development of
alternative hypotheses, but so far none have been able to dethrone CDM.
This is partly due to the presence of baryons in galaxies, whose
feedback processes and radiative properties are far more complex than
the physics of dark matter. In the presence of baryonic feedback, many
dark-matter models start losing their distinctive profiles, leaving us
unable to distinguish between them.

One promising way out of this conundrum is to study dark matter in
environments with as few baryons as possible. Ultra-faint dwarf
galaxies (UFDs) are the faintest, least massive, and most dark
matter–dominated galaxies known. They are predicted to have dark-matter
distributions unchanged by baryonic feedback.

In this colloquium I will present the current state of research to
constrain the nature and properties of dark matter using UFDs, including
the first results from a novel 100-hour MUSE survey of UFDs. I will
address the constraints on primordial black holes from their dynamical
effects on stellar distributions, as well as the constraints on various
types of particulate dark matter (weakly interacting massive particles,
axion-like particles, self-interacting dark matter, and fuzzy dark

matter) from emission-line searches and the first determined dark matter–density profile of a UFD. I will end with an outlook for the near future of this field.

Sebastiaan L. Zoutendijk

observational cosmologist

Education

2017–present	**Doctor**, *Leiden University*, Leiden, Netherlands. Thesis (expected 2021): Constraints on dark matter from ultra-faint dwarf galaxies.
2015–2017	**Master of Science in Astronomy**, *Leiden University*, Leiden, Netherlands. Specialization: Astronomy and Cosmology. Thesis: "Maximum likelihood analysis of galaxy–galaxy lensing: A comparison of one- and two-dimensional methods using EAGLE simulations".
2012–2015	**Bachelor of Science in Physics & Bachelor of Science in Astronomy**, *Leiden University*, Leiden, Netherlands, *cum laude*. Thesis: "C_6H electronic spectra and comparison with diffuse interstellar bands".

Teaching experience

2017–2020	**Teaching assistant**, *Leiden University*, Leiden, Netherlands. Introduction Astrophysics (3 semesters).

Administrative experience

2019–present	**Institute Council**, *Leiden Observatory*, Leiden, Netherlands. Co-representative for PhD candidates.
2018	**PhD talks**, *Leiden Observatory*, Leiden, Netherlands. Co-organizer of informal scientific presentations among PhD candidates.
2016–2017	**Education Committee**, *Leiden Observatory*, Leiden, Netherlands. Representative for Dutch astronomy master's students.

Observing experience

2018	VLT/MUSE, 5 half-nights as visiting astronomer.
2014	INT/WFC, 4.5 hours observing, 4 nights in the control room.

Outreach

2020	**Dark matter in the smallest galaxies**, *Astronomy on Tap Leiden*, Leiden, Netherlands, talk.

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PUBLICATIONS

internal review — **The MUSE-Faint survey. II. The dark matter–density profile of the ultra-faint dwarf galaxy Eridanus 2**.
Sebastiaan L. Zoutendijk et al.
Under internal review by the MUSE Collaboration.

submitted — **Searching for Light in the Darkness: Bounds on ALP Dark Matter with the optical MUSE-Faint survey**, *Phys. Lett. B*, arXiv:2009.01310.
Marco Regis, Marco Taoso, Daniel Vaz, Jarle Brinchmann, **Sebastiaan L. Zoutendijk**, Nicolas Bouché, and Matthias Steinmetz.

2020 — **The MUSE-Faint survey. I. Spectroscopic evidence for a star cluster in Eridanus 2 and constraints on MACHOs as a constituent of dark matter**, *A&A*, 635, A107.
Sebastiaan L. Zoutendijk, Jarle Brinchmann, Leindert A. Boogaard, Madusha L. P. Gunawardhana, Tim-Oliver Husser, Sebastian Kamann, Andrés Felipe Ramos Padilla, Martin M. Roth, Roland Bacon, Mark den Brok, Stefan Dreizler, and Davor Krajnović.

2019 — **The case for two-dimensional galaxy–galaxy lensing**, *A&A*, 627, A74.
Andrej Dvornik, **S. L. Zoutendijk**, Henk Hoekstra, and Konrad Kuijken.

CONFERENCE CONTRIBUTIONS

2020 — **Constraining dark matter in the ultra-faint dwarf galaxy Eridanus 2 using MUSE-Faint**, *European Astronomical Society Annual Meeting*, virtual, e-poster.
Sebastiaan L. Zoutendijk, Jarle Brinchmann, and The MUSE Collaboration.

2018 — **Spectroscopic evidence for a star cluster in the ultra-faint dwarf Eridanus 2**, *Netherlands Astronomers' Conference*, Groningen, Netherlands, poster.
Sebastiaan L. Zoutendijk, Jarle Brinchmann, Leindert A. Boogaard, Tim-Oliver Husser, Sebastian Kamann, Andrés Felipe Ramos Padilla, and The MUSE Collaboration.

EXTERNAL COLLOQUIA

2019 — **Constraining dark matter using MUSE observations of ultra-faint dwarf galaxies**, *Centro de Astrofísica da Universidade do Porto*, Porto, Portugal, Cookie Seminar.