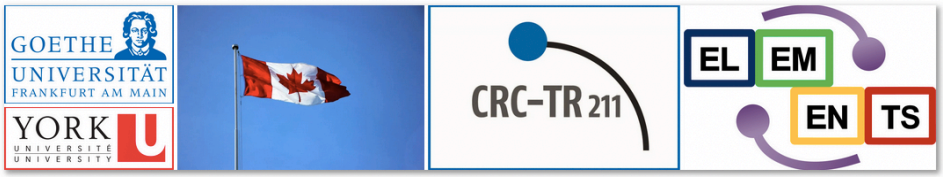
EXPLORE 2022 Workshop: Astrophysical Laboratories of Fundamental Physics



Report of Contributions

https://indico.global/e/6715

Contribution ID: **1** Type: **not specified**

Welcome

Tuesday 29 March 2022 14:30 (15 minutes)

Presenters: SAGUNSKI, Laura (Goethe University); TULIN, Sean (York University)

Contribution ID: **2** Type: **not specified**

EXPLORE project: ”Probing Dark Matter with Gravitational Waves ” (Dark Matter Team)

Tuesday 29 March 2022 16:15 (1 hour)

Chair: Edwin Genoud-Prachex
Co-Chair: Nassim Borzognia

Mentors: Laura Sagunski, Saeed Rastgoo
Junior mentors: Adam Smith-Orlik, Niklas Becker

On Sep 14, 2015, a dramatic event has taken place. LIGO has detected the first graviational waves of a binary black hole merger and thus started the era of gravitational wave astronomy.
Seeing the universe with these new eyes opens up countless possibilties to test our theories and make new detections. One of the most intriguing detections would be dark matter!

Massive black holes at the centers of clusters or galaxies are surrounded by gigantic dark matter halos. Near these black holes, the dark matter density can be extremely high and form a so-called dark matter density spike. Due to its extremely high density, the dark matter density spike creates a violent environment around the black hole. If the black hole then merges with a smaller companion object, the presence of the dark matter density spike will drastically affect the binary merger dynamics. In particular, it will leave an imprint on the emitted gravitational wave signal. If we detect such a signal, we can thus probe the nature of dark matter with gravitational waves!

Main tasks: 1. Model the profile of the dark matter density spike around the black hole for different dark matter models (cold dark matter, self-interacting dark matter) in Newtonian gravity and then include relativistic effects. (Dark Matter Group)
2. Model the merger dynamics and the gravitational wave signal including post-Newtonian corrections. (Gravity Group)
3. Compute the gravitational wave signal for different dark matter models, check its detectability with current and future gravitational wave detectors (LIGO, LISA) and constrain the particle nature of dark matter with gravitational waves. (Gravity Group)

Author: SAGUNSKI, Laura (Goethe University)

Co-authors: SMITH-ORLIK, Adam (York University); BECKER, Niklas (Goethe University)

Presenters: GHASEMIDZADEH, Romina (Goethe University); MANSOUR, Ethar (Goethe University); NOEL, Majd (York University); PÖPLAU, Johannes (Goethe University)

Contribution ID: **3** Type: **not specified**

Invited talk on ”Neutron Stars: Astrophysical Probes of Extreme Matter”

Tuesday 29 March 2022 14:45 (45 minutes)

Chair: Laura Sagunski

Neutron stars are among the most fascinating and intriguing objects in the Universe. These compact objects contain matter in the densest and coldest form, possess ultrastrong magnetic fields and display ultrahigh velocities. These astrophysical laboratories effectively allow us to investigate properties of matter under the most extreme conditions, far beyond the reach of terrestrial experiments. While multi-wavelength astronomical observations provide us a wealth of data about them, the recent detection of gravitational waves emitted by neutron stars is allowing us for the first time to probe their interior composition directly. Together, these tools of multi-messenger astronomy of neutron stars have opened up a window to an unforeseen Universe.

Presenter: CHATTERJEE, Debarati (IUCAA, Pune, India & Chair LIGO-India EPO)

Contribution ID: **4** Type: **not specified**

Discussion session for EXPLORE students

Tuesday 29 March 2022 17:30 (1 hour)

Chair: Nassim Bozorgnia

Presenters: BOZORGNIA, Nassim (York University); RASTGOO, Saeed (York University); SAGUNSKI, Laura (Goethe University); SCHAFFNER-BIELICH, Jürgen (Goethe University); TULIN, Sean (York University)

Contribution ID: **5** Type: **not specified**

EXPLORE project: ”Probing Dark Matter with Gravitational Waves ” (Dark Matter Team)

Contribution ID: **6** Type: **not specified**

EXPLORE project: ”Probing Dark Matter with Gravitational Waves ” (Gravity Group)

Thursday 31 March 2022 16:15 (30 minutes)

Chair: Jürgen Schaffner-Bielich

Mentors: Saeed Rastgoo, Laura Sagunski
Junior mentors: Robin Diedrichs, Niklas Becker

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Author: RASTGOO, Saeed (York University)

Co-authors: BECKER, Niklas (Goethe University); DIEDRICHS, Robin (Goethe University)

Presenters: GARG, Nifia (York University); KHAN, Hazkeel (York University)

Contribution ID: **7** Type: **not specified**

EXPLORE project: ”Dark Stars”

Thursday 31 March 2022 17:00 (1 hour)

Chair: Robin Diedrichs
Co-Chair: Saeed Rastgoo

Mentors: Jürgen Schaffner-Bielich, Nassim Bozorgnia, Sean Tulin
Junior mentors: Daniel Schmitt, Edwin Genoud-Prachex

Dark matter structures are known to span from dwarf
galaxies to the large scale structure of the cosmic web.
But there is an uncharted territory: Do dark matter structures exist on (much) smaller scales?
The research goals are divided in
• Study of dark star properties
• Derive observational constraints on dark stars from tidal streams

Dark stars properties are investigated along these lines:
• What are the properties of dark matter stars?
• Solve the Tolman-Oppenheimer-Volkoff
equations and derive mass-radius relations
• Calculate the I-Love-Q relations of dark stars
and compare to the one of neutron stars

Dark stars passing through the stream cause dynamical heating.
The gravitational encounters impart random kicks to stream stars.
A limit on dark stars using observed velocity dispersion of GD-1 stream can be derived.
The constraint is not just for dark stars, but for any compact
dark object as primordial black holes and MACHOs (Massive Compact Halo Objects).
The goal is to derive (and publish) new general exclusion limit.
Phase 1: Analytic calculation
• Compute dynamical heating of streams from compact objects
• Point-like objects (black holes), finite objects (dark stars)
→Use mass-radius relation
Phase 2: Numerical simulation
• Simulation of tidal stream + encounters from compact objects
• Goal: numerical validation of analytic results
Phase 3: Data analysis
• Explore Gaia data for calculating GD-1 stream velocity
dispersion (reproducing known results)

Authors: SCHAFFNER-BIELICH, Juergen (Goethe University); BOZORGNIA, Nassim (York University); TULIN, Sean (York University)

Co-authors: SCHMITT, Daniel (Goethe University); GENOUD-PRACHEX, Edwin (Goethe University)

Presenters: ANDARGE, Eyosyas (York University); MOORTHY, Subbashivani Ganesa (York University); PARSONS, Joshua (York University); THAKKAR, Dhyan (York University)

Contribution ID: **8** Type: **not specified**

Announcements (visit at Goethe University, prize)

Thursday 31 March 2022 16:00 (15 minutes)

Authors: SAGUNSKI, Laura (Goethe University); BOZORGNIA, Nassim (York University); RASTGOO, Saeed (York University); SCHAFFNER-BIELICH, Jürgen (Goethe University); TULIN, Sean (York University)

Presenters: SAGUNSKI, Laura (Goethe University); BOZORGNIA, Nassim (York University); RASTGOO, Saeed (York University); SCHAFFNER-BIELICH, Jürgen (Goethe University); TULIN, Sean (York University)

Contribution ID: **9** Type: **not specified**

Social event

Thursday 31 March 2022 18:00 (1 hour)

Presenters: BECKER, Niklas (Goethe University); DIEDRICHS, Robin (Goethe University); GENOUD-PRACHEX, Edwin (Goethe University); SCHMITT, Daniel (Goethe University); SMITH-ORLIK, Adam (York University)

Contribution ID: **10** Type: **not specified**

Discussion round with the speaker

Tuesday 29 March 2022 15:30 (30 minutes)

Presenter: CHATTERJEE, Debarati (Pune University)