Program FYSICA 2019
Friday, April 5
Amsterdam Science Park
www.fysica.nl

Title: **Astroparticle physics and cosmology**

Abstact: In the past decades, our understanding of the origin and history of the universe and the extreme processes it contains has greatly expanded. Nevertheless, many questions, such as the question of what dark matter consists of, what dark energy actually is, when and how the first stars and galaxies were formed, and how matter behaves in the vicinity of strong gravitational fields, remain. In this parallel session, the four speakers will provide updates about recent progress at a variety of research fronts connected to gravitational waves, the formation of the first stars and the nature of dark matter, as well as expectations for the upcoming years.

The pioneering discovery of the first gravitational wave signals with the LIGO and Virgo detectors since September 2015 (Nobel Prize 2017) kicked off the bustling field of gravitational wave astrophysics. In particular the first observation of a merger of binary neutron stars has lead to spectacular signatures and insights, since it was observed also over the entire electromagnetic spectrum (radio, infrared, optical, ultraviolet, X-ray and gamma radiation), confirming for instance that the fusion of neutron stars can generate so-called gamma-ray bursts. The intergalactic medium in today's universe is highly ionized. Driving force for the (re-)ionization during the first billion years after the Big Bang was the formation of the first stars and galaxies, which generated large amounts of ionizing ultraviolet radiation. The "21 cm" radio emission of neutral hydrogen in the early universe is a promising upcoming probe for this infant state of the universe, and is measurable by low-frequency radio telescopes such as the Dutch LOFAR or the future SKA in South Africa. Dark matter particles that continuously flow through the earth are expected to occasionally give a small kick to atomic nuclei or the surrounding electrons. These extremely rare and difficult to measure events are exactly what the XENON1T experiment is looking for, by searching for the scintillation light of such interactions. In many cases it is also expected that dark matter particles annihilate into a flash of gamma ray photons and other high-energy particles once they meet in environments with high dark matter density. Astronomical observations of gamma rays, observations of energetic neutrinos and measurements of charged cosmic rays can be used to search for traces of this process.

Convener: Sarah Caudill (Nikhef)

Speakers (in order of appearance)

Title: **Seeing and hearing the violent universe: the rich physics of compact object mergers**

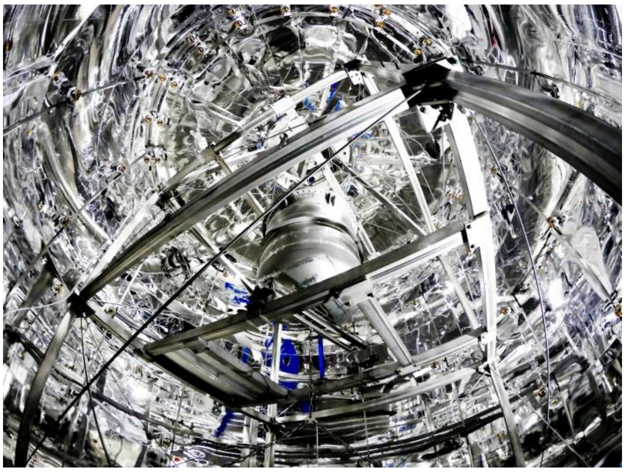
Samaya Nissanke (UvA)

Abstract: In the past two years, the LIGO and Virgo gravitational wave detectors have discovered ten binary black hole mergers as well as the the first binary neutron star merger GW170817. The FERMI gamma-ray monitor independently detected a gamma-ray burst within two seconds with respect to the merger. Instigated by the event's gravitational wave localization volume, telescopes across all wavebands in the electromagnetic spectrum observed the ensuing event's post-merger emission.

In this talk, I will first describe the multi-messenger observations of this binary neutron star and then discuss how to place compact object mergers in their full astrophysical context with multi-messenger observations. I will highlight the challenges we face in explaining the rich physics driving the merger in high velocity, strongly-curved spacetime in Universe. I will conclude with the unprecedented opportunities that are opening up in strong-field dynamic gravity astrophysics thanks to multi-messenger astrophysics during the next few years and decades.

Title: **XENON1T: When all other lights go out**

Jelle Aalbers (Stockholm University – formerly at Nikhef)



Abstract: Dark matter is a crime with too many suspects. While cosmology and astrophysics show ~80% of matter is 'dark matter', theorists have many ideas on what particle this consists of. The XENON1T experiment tests these ideas, using a large vat of liquid xenon in which ambient radioactivity is brought down to record low levels. We hope to see rare, extremely small light flashes of dark matter scattering off regular matter. However, we are sensitive to other rare signals too. This talk presents the experiment and its latest results -- what we see when all other lights go out.

Title: **Indirect dark matter searches: status and perspectives**

Manuela Vecchi (RUG)

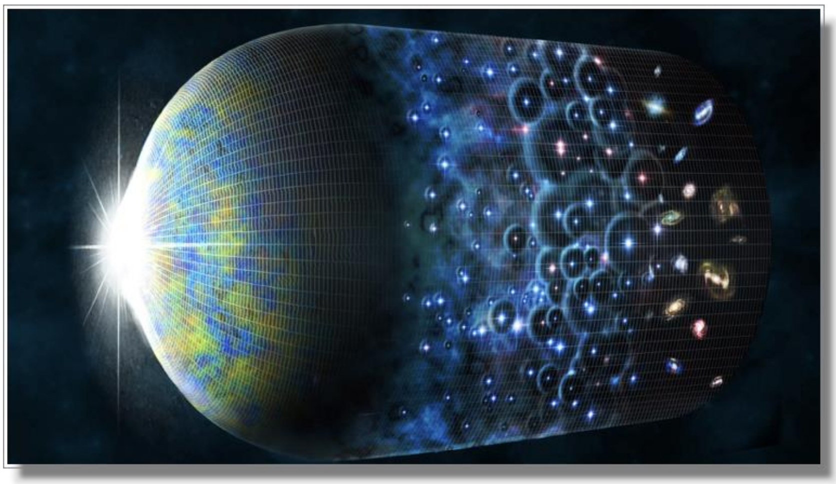
Abstract: The existence of dark matter (DM) is supported by a large body of evidence, on local and cosmological scales, collected over the past decades. However, we still have very limited knowledge about its nature and interaction mechanisms. If Dark Matter is made of weakly interacting massive particles (WIMPs), indirect searches are extremely promising method with which to probe annihilating and decaying dark matter particle models, with masses in the GeV to TeV region.

Indirect searches can be carried out by looking for an excess of gamma rays or neutrinos coming from DM-dominated regions, like the galactic center or dwarf galaxies. The search for DM with charged cosmic rays can be performed by searching for spectral features in the antimatter fluxes, where the DM signal would appear as an excess with respect to the background from conventional astrophysical processes.

In this talk I will provide an overview of the latest results on the DM interpretation of the cosmic ray positrons and antiprotons flux measurements, as well as the perspectives for the search of light antinuclei. Concerning the search for dark matter with gamma rays, I will discuss the latest results and I will present the future perspectives in view of the upcoming Cherenkov Telescope Array.

Title: **From the Cosmic Dawn to the Epoch of Reionization: a Radio Quest for Neutral Hydrogen in the Infant Universe**

Leon Koopmans (RUG)



Abstract: Detection of the redshifted 21-cm signal of neutral hydrogen from the Cosmic Dawn and Epoch of Reionization (EoR) promises a new avenue to study physical processes of early star and galaxy formation during the first billion years of the Universe. These eras form the foundation of our present-day observable universe. The quest for a detection of this 21-cm signal has been exceedingly hard with current radio telescopes, and has not yet been achieved, although steady progress is being made.

I will give an overview of what can be learned from observing these early phases of the infant Universe as well as a broad overview of ongoing experiments aiming to detect this feeble signal. In particular, I will provide a status update on the LOFAR EoR Key Science project and the challenges

that it and other similar projects are facing. I will show that considerable progress has been made in the last years, but that not all challenges have yet been met. I will end by introducing several exciting new projects that we have recently started, to observe the Cosmic Dawn and the Dark Ages, and give a glimpse of future opportunities with the SKA and HERA.