Chapter 1 : Namir E. Kassim (Author of Low Frequency Astrophysics from Space)

Low Frequency Radio Astronomy From Space The opening of a new spectral window for astronomical investigations has always resulted in major discoveries, significant insights into astrophysical processes, and an enrichment of our understanding of the universe.

The signals from this epoch are sufficiently faint that they may be detectible only from the radio-quiet lunar farside. The LUNAR team is developing the scientific motivation and technologies to be able to conduct these observations. The neutral hydrogen molecules had an almost perfectly uniform distribution across the Universe. One billion years later, the Universe was rich with structure, and the primordial gas had been enriched by heavy elements created by stars and supernovae. Almost all of this gas had been ionized had its electrons stripped away by the first stars and galaxies, and heated by radiation from X-ray sources such as the accretion discs of black holes. The later epoch is coming within observational range of our largest ground-based telescopes, as well as the Hubble Space Telescope. However, the billion year period between them remains far more mysterious. Astronomers typically divide this billion year period into three eras: The best hope for observing this period is the cm radiation signal from hydrogen. Neutral hydrogen has two electrical states, and radiation is emitted when the atom transitions from the higher state into the lower state. In a terrestrial laboratory, this radiation has a wavelength of 21 cm, or a frequency of MHz. However, the 21 cm radiation from the early Universe is highly redshifted, so that by the time it reaches Earth it is at low radio frequencies, less than around MHz. The team is developing tools and instrumentation to observe this radiation and subtract foreground noise. Teammembers are also conducting theoretical studies of the early Universe, to model the signal. The Universe evolves in time from left to right. The top panel shows the structures visible in neutral hydrogen, blue being cold gas, red being hot gas, with black regions either being ionized no neutral hydrogen or at the same temperature as the cosmic microwave background. Major epochs are also marked. Since the signal the LUNAR team hopes to observe was emitted billions of years ago, it is very faint when viewed from Earth. Terrestrial radio sources, such as FM radio stations, military and commercial satellites, and many others, all interfere with astronomical signals,effectively drowning out the cosmological radiation the team aims to observe. Therefore, the radio sensing equipment must sit on or orbit around the lunar farside, which has been proven to be the only radio-quiet location in the nearby solar system. Designing a lunar telescope has been a dream of many scientists for decades, and the LUNAR team is working on a design that is durable in the lunar environment and cost effective to deploy and operate. Theoretical tools The team is simulating the early Universe using state-of-the-art modeling tools, such as the cosmological hydrodynamic simulation code Enzo see Figure 3. This helps us to understand physical processes in the early Universe, and to generate predictions for what a low-frequency radio observatory on the Moon will see. Now, having integrated the capabilities of an inline friends-of-friends dark matter halo finder with new radiative transfer modules in the cosmological code Enzo, these simulations can generate a population of AGN that evolve naturally in tandem with the dark matter density field. X-ray emission from these AGN is propagated using an adaptive ray-tracing algorithm and is coupled to the hydrodynamics and chemistry solvers within Enzo, allowing the study the resultant heating and ionization and thus cm signal in detail. This is a snapshot of the Enzo code showing the radiative transfer of X-ray emission in the early Universe. UV and X-ray light were responsible for the heating of the Early Universe. Much research has been conducted to model what the predicted 21 cm signal will look like when a radio instrument is sent into space. The cm signal contains structures on extremely large scales, however, and so even low resolution images will provide valuable information about the structure of matter early in the Universe. This has two important implications for low-frequency telescopes. It also means that these exotic stars are likely to exist only in the earliest phases of cosmic history, so telescopes like a lunar array are essential to understanding their properties. The signals from the antennas in this array will be combined to form a huge low-frequency radio telescope. The Lunar Radio Array will require a large number of science antennas, so a high sensitivity per unit mass is a key requirement. This will save on the construction and deployment costs, since sending a kilogram of material to the Moon is exceedingly expensive. The yellow arm is made of a extremely thin sheet of Kapton film. The dipoles are connected by an electric transmission line to the central hub, shown in purple. This hub transmits the data back to Earth. Figure 5 shows the vacuum chamber in which team members are testing a polyimide film antenna. Dipoles are printed onto a plastic film, which can then be rolled out onto the lunar surface by astronauts or a remotely operated rover. Several experiments to date have confirmed that Kapton, a thermally insulating polyimide film, is the best material to use for the antennae arms. It is durable under the extreme temperature varuations, low atmospheric pressure, and extreme ratiation environment at the lunar surface. The team is considering possible upgrades to the chamber to include lunar simulant and an electron beam to more fully replicate the lunar surface conditions. You can view the descriptions and results of these experiments HERE. The vacuum chamber LUNAR Simulation Laboratory used to test how well a polyimide film antenna can stand up to the rigors of the lunar environment. These tests are useful to test the deployment of large sections of film and deployment systems with many moving pieces. The team is working on developing space-quality systems to more accurately test these deployment scenarios. Figure 6 shows the Kapton film in one such test. A backyard test unrolling of the Kapton film. This strip of film is much longer than what can be acomodated in the LSL vacuum chamber. Array Concepts and Algorithm Development The Lunar Radio Array must be designed so that it can achieve its science goals, and is robust enough to survive the extreme lunar surface environment. LUNAR is studying how to optimize the layout of the antennas in a future lunar radio telescope. The image below shows the layout that maximizes scientific return with the least amount of mass. Each dot represents a single antennae, which is a Y shaped structure with three flexible arms each containing hundreds of photon collecting dipoles. The entire array stretches for hundreds of kilometers. LUNAR also studied concepts for low-mass transmission lines that could be used with passive low frequency antennas on the lunar surface. Missions A spacecraft orbiting over the far side of the Moon experiences many of the benefits of a telescope placed on the lunar surface. Please click on the image below to visit the DARE site.

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Chapter 2 : Low Frequency Radio Group

Low Frequency Astrophysics from Space: Proceedings of an International Workshop Held in Crystal City, Virginia, USA, on 8 and 9 January (Lecture Notes in Physics) Softcover reprint of the original 1st ed. Edition.

Lightning Radio Emissions Listen to an audio demo Did you know that here in Atlanta we can easily observe lightning from almost anywhere on the planet? This is because lightning releases intense low frequency radio waves that propagate globally, reflecting from an upper atmospheric electrically charged layer known as the ionosphere. Global Field Experiments Studying a solar eclipse The wondrous Earth is our laboratory, and the low frequency radio wave is our microscope to understand the her natural electricity. We enjoy travelling to conduct our experiments. We operate receiver sites all over and bring the data back to analyze using advanced signal processing. Radio Receiver Design Live low frequency data We build hardware, too! We design our own radio reciever, the most sensitive radio receivers you can find in this band, capable of detecting even weak lightning activity from thousands of miles away. Hands-on work is shared as a team effort by the whole group. Next-Gen Antennas Generating low frequency waves for global communications and navigation ordinarily requires enormous antennas covering thousands of acres. We are rethinking and redefining the antenna with novel approaches, with potential implications to radars and other electromagnetic applications. Navigation and Comms Learn about the ionosphere Because low frequency waves travel globally, they have practical uses. Long before GPS existed, engineers used low frequency waves broadcast from radio stations to determine location anywhere on the planet. And various navies have been using low frequency waves to communicate with submarines across an entire ocean. There are bands of intense radiation originally from the sun that surround the Earth, which bombard and destroy satellite electronics. It turns out that low frequency waves may hold the key to understanding how these radiation belts form and evolve. And when radio waves, particularly at low frequencies, propagate through plasmas, really interesting things happen. We merge observations with theoretical models. High Altitude Ballooning See video from the balloon Why confine ourselves to the ground? We lead an undergraduate team of researchers building high-altitude , ft balloons equipped with sensors cameras, x-ray, electromagnetic , to study lightning and other upper atmospheric phenomena from above. Students earn credit and can stay on the team for years.

Chapter 3 : Low Frequency Astrophysics from Space | In-Stock - Buy Now | at Mighty Ape Australia

Leading experts give an overview of very low frequency radio astronomy. They present for the first time in a single conference the astrophysical need for and possible instrumentation for implementing ground-based, ground-to-space, space-based, and lunar-based observations.

Chapter 4 : Low Frequency Astrophysics & Cosmology â€¢ Lunar University Network for Astrophysics Res

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