Julius-Maximilians-Universität Würzburg

Report on JIVE VLBI School and WE-Heraeus and NARIT Cosmology School

Report submitted
within the Master's Program in
Satellite Technology - Advanced Space Systems

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1 | Introduction

In September and October 2025, I had the opportunity to participate in two international summer schools in the field of radio astronomy and cosmology: The *JIVE VLBI School 2025* in Dwingeloo, the Netherlands (September 15 – 19), and the *WE-Heraeus and NARIT Cosmology School 2025 – Galaxies and Beyond* in Chiang Mai, Thailand (October 13 – 17). Both programs provided valuable insights into observational techniques and current research topics in astrophysics, ranging from the practical calibration of radio interferometric data to the theoretical frameworks of cosmology. In addition to the scientific content, both events offered an excellent environment for international collaboration and exchange with students from around the world.

2 | JIVE VLBI School 2025 - Dwingeloo, Netherlands

The JIVE VLBI School 2025 was held at the ASTRON and JIVE facilities in Dwingeloo, located next to the Dwingeloo 25-meter radio telescope and near the Westerbork Synthesis Radio Telescope (WSRT). Participants came from across Europe, Asia, Africa, and South America, representing all academic levels from Bachelor's students to postdoctoral researchers.

The school began with introductory lectures on the fundamentals of Very Long Baseline Interferometry (VLBI), data correlation, and the principles of radio interferometry. During the first two days, we gained a theoretical foundation on how multiple telescopes are synchronized to achieve high angular resolution, how data are correlated across large baselines, and how phase and amplitude calibration affect the final image quality.

A highlight of the week was the visit to both the Dwingeloo 25-meter telescope (Fig. 1) and the WSRT (Fig. 2), where we were able to take part in an actual VLBI observation as part of the European VLBI Network (EVN). The observed source was 3C395, an active galactic nucleus frequently used as a calibration and test target.

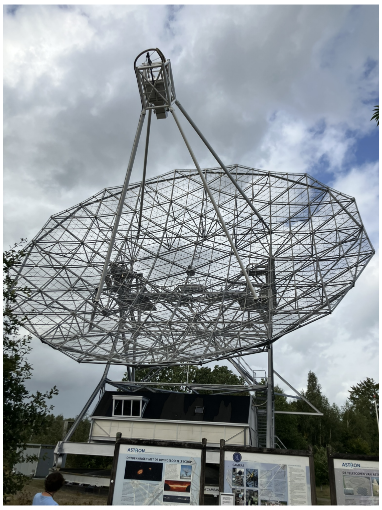

Figure 1: The 25m Dwingeloo Telescope.

Figure 2: Group picture at WSRT.

Figure 3: The Jive Correlator

From the third day onward, the focus shifted to data processing. Using the correlated data from the observation, we practiced calibration, imaging, and model fitting. Conducting this analysis ourselves clearly demonstrated the challenges of VLBI data reduction: since we measure interference patterns rather than direct images, each pair of telescopes provides only a single point in the Fourier plane. As the Earth rotates, the projected baselines change, and these measurements gradually fill parts of the Fourier space, tracing so-called uv-tracks. However, because of atmospheric fluctuations and instrumental uncertainties, the measured visibilities are never perfect. Therefore, a simple inverse Fourier transform would not yield a meaningful image. Instead, we fit models to the data and iteratively refine them to obtain the most plausible brightness distribution. The reconstruction process thus relies strongly on experience and on carefully directing the model. For me, it was fascinating to realize how much interpretation and iterative adjustment are required to derive a scientifically meaningful image from raw interferometric data. At the end of the school, each group presented its reconstructed image and discussed its approach and results. My calibrated image can be seen in Figure 4.

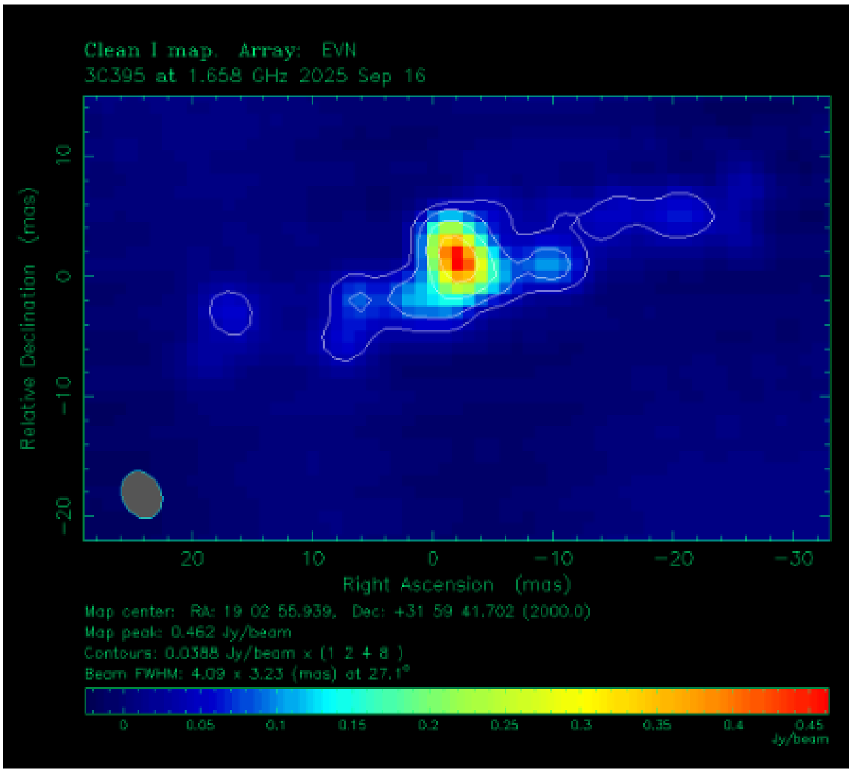

Figure 4: My calibrated image of 3C395

Beyond the academic sessions, the school also provided opportunities for networking and informal exchange. Despite the unpredictable Dutch weather (which included rain, hail, thunderstorms, and a few sunny hours) the atmosphere was very positive. I quickly discovered that two of the participants, Teep and Kritsada, were from Chiang Mai, working at the National Astronomical Research Institute of Thailand (NARIT), where my second summer school in October was to take place. As preparation for Thailand, they already gifted me two authentic and extremely spicy Thai noodle soups. Overall, the JIVE VLBI School 2025 offered an ideal combination of lectures, hands-on work, and informal discussions. It significantly deepened my understanding of radio interferometry and provided valuable practical experience with real VLBI data.

3 | WE-Heraeus and NARIT Cosmology School 2025 – Galaxies and Beyond - Chiang Mai, Thailand

Just a few weeks later, I participated in the *WE-Heraeus and NARIT Cosmology School – Galaxies and Beyond* in Chiang Mai, Thailand. The program focused on galaxy formation, cosmology and observational astrophysics and gathered more than 130 participants, making it significantly larger in scale than the Dwingeloo school (which hosted about 30 participants on-site, in addition to online attendees).

Since I already had several contacts at NARIT - including a postdoctoral researcher from Würzburg who had studied in Chiang Mai and the two participants from Dwingeloo - I arrived one week earlier to visit the institute, the Thai National Radio Telescope (TNRT), and the city. I was warmly welcomed by Teep and Kritsada, who met me at the train station as I arrived by night train from Bangkok early in the morning (Fig. 5). After a quick breakfast at a local street-food restaurant, they gave me a detailed tour of the NARIT campus, including its laboratories and cleanrooms. I was particularly interested in the ongoing CubeSat projects, which are currently awaiting launch funding (Figure 6).

Figure 5: Train Bangkok -> Chiang Mai

Figure 6: satellite clean room at NARIT

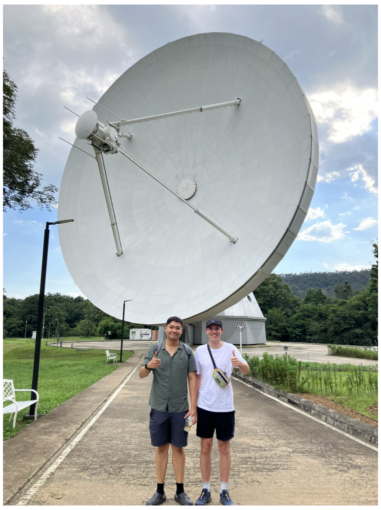

Figure 7: Thai National Radio Telesope (TNRT)

On Friday, I visited the 40-meter telescope located outside the city, surrounded by jungle. Teep showed me around the control room, backend electronics, and data center. I was impressed by the logistical complexity of maintaining such a large instrument in a humid and remote environment, where even small spare parts must be kept in stock to avoid long downtimes. Fortunately for me, the telescope was undergoing receiver maintenance, so I was even allowed to steer it to take some photographs together with Jompoj and Teep (Figure 7).

Once the summer school began, the schedule was densely packed with lectures, workshops, and presentations. Each morning started with two major lectures, beginning with galaxy formation and observational constraints, followed by topics such as pulsars, dark matter, and dark energy. In the afternoon, we participated in hands-on sessions where we simulated the formation and evolution of the universe. We began with simple two-dimensional gravitational particle simulations, observing how structures like clusters, galaxies, and voids emerged naturally. Later, we refined the models by adding hydrodynamical effects, eventually obtaining realistic cosmological simulations.

Figures 8–11 show the simulated particle distribution, velocity dispersion, density, and (for the hydrodynamical case) the temperature field. The particle evolution can also be seen in a short video (Simulations), where the gravitational collapse and subsequent formation of dense clusters become apparent.

A comparison between the density and velocity dispersion maps shows that both quantities correlate strongly: Dense regions exhibit higher velocity dispersion, which indicates that these areas are dynamically hotter. The hydrodynamical simulation further confirms this behavior: The gas temperature follows the density field closely, increasing in high-density regions due to compression and shock heating. This trend is qualitatively consistent with what is observed in real large-scale structures.

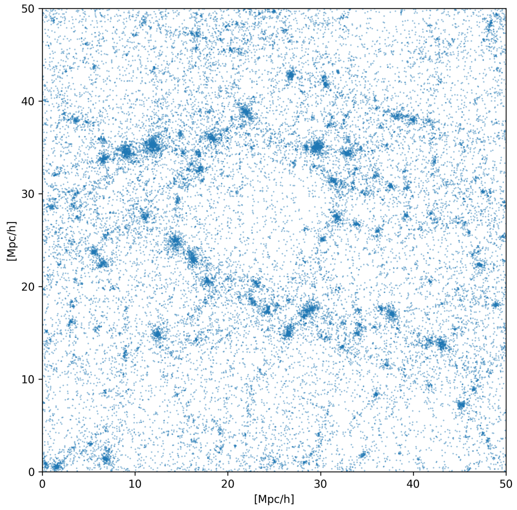

Figure 8: Particle distribution from the two-dimensional N-body simulation showing the emergence of clusters and voids.

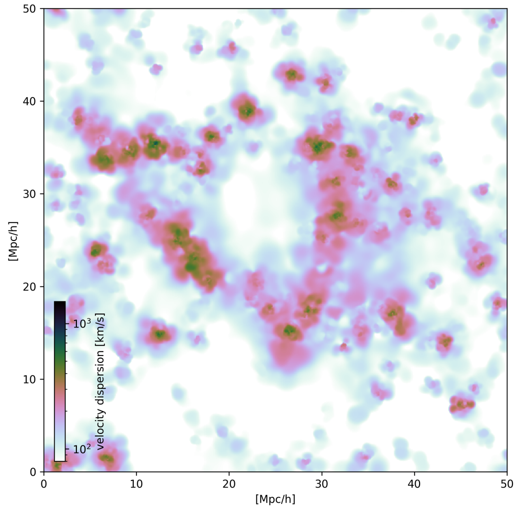

Figure 9: Velocity dispersion map corresponding to the particle distribution. Higher dispersion indicates dynamically hotter, denser regions.

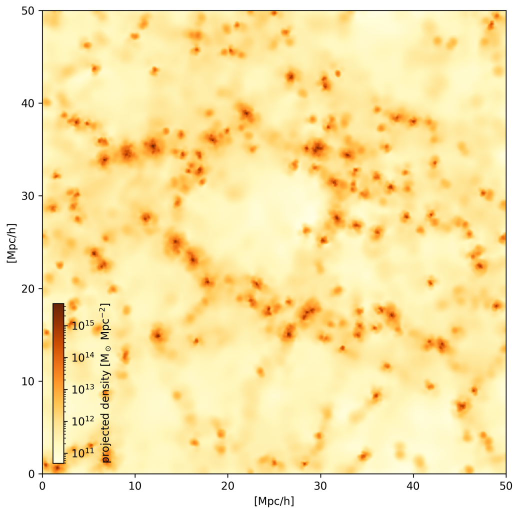

Figure 10: Density projection showing strong clustering and large-scale voids.

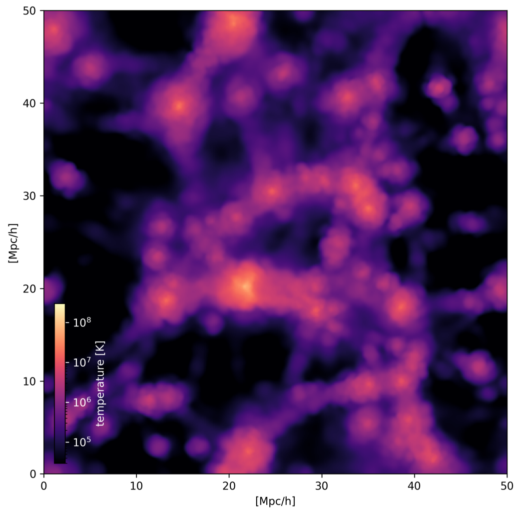

Figure 11: Temperature field from the hydrodynamical simulation.

Each afternoon also included short student presentations of approximately four minutes each. During my own talk, I presented parts of my Bachelor's thesis research (the search for positronium recombination lines as a potential probe of light dark matter) and discussed possible future projects, such as the planned 18-meter telescope on the Zugspitze in Germany (Figure 12).

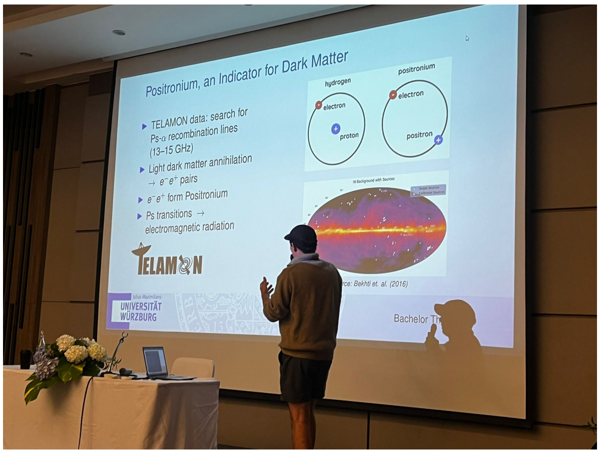

Figure 12: My short presentation

Figure 13: NARIT planetarium

On Wednesday, we had an excursion to NARIT, where we visited the planetarium (Figure 13) and additional facilities. We saw how the MAGIC mirrors for the Cherenkov Telescope Array on La Palma are manufactured (Figure 14) and learned about the construction of a 0.75-meter optical telescope designed as a cost-efficient instrument for global deployment. In the evening, the Conference Dinner provided an opportunity to relax and exchange ideas in an informal setting, featuring traditional Northern Thai cuisine and live music.

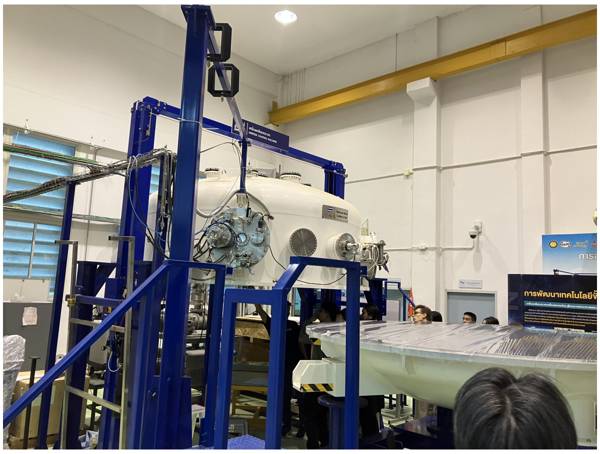

Figure 14: Mirrow fabrication of MAGIC Telescopes

Figure 15: Typical Songthaews Taxi.

Beyond the scientific program, the cultural experience was equally enriching. From exploring Chiang Mai's many temples to trying out local dishes such as Pad Kra Pao and Mango Sticky Rice, the week offered many memorable impressions. The red "Songthaews" (converted pickup trucks functioning as shared taxis, seen in Figure 15) quickly became my favorite means of transport. On the final evening, we visited a large night market, shared food and stories with fellow participants, and exchanged contact information for future collaborations.

4 | Final Remarks

Participating in the JIVE VLBI School and the WE-Heraeus and NARIT Cosmology School was a highly rewarding experience, both scientifically and personally. In Dwingeloo, I gained hands-on experience with interferometric data and learned how observational radio astronomy is conducted in practice. In Chiang Mai, I expanded my understanding of cosmology and galaxy formation while gaining a global perspective on how astronomical research is organized and carried out in different parts of the world.

In both schools, I greatly enjoyed collaborating and exchanging ideas with students and researchers from diverse backgrounds. Overall, these two weeks have strengthened my interest in the interface between observational astrophysics and computer science and have provided valuable motivation and context for my future research.