

# NIMFEIA

## Deliverable D1.11

### Dissemination and Exploitation Plan 3

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## 1. Introduction

This document is the fourth version of the Dissemination and Exploitation Plan (DEP) of the project *Nonlinear Magnons for Reservoir Computing in Reciprocal Space* (NIMFEIA), funded by the European Union under the call *HORIZON-CL4-2021-DIGITAL-EMERGING-01-14 - Advanced spintronics: Unleashing spin in the next generation ICs (RIA)* with grant agreement number 101070290. NIMFEIA started in October 2022 and will run for four years. Its main objective is to provide a novel hardware solution for brain-inspired reservoir computing using magnetic materials on the nanoscale combined with advanced spintronic technologies.

This plan is written against the background of the NIMFEIA objectives with the purpose to define the dissemination and exploitation activities to be carried out during the project.

## 2. Dissemination activities

To promote the NIMFEIA project and its results, we identify different target groups, each requiring a different presentation approach.

### 2.1. General public

To reach the general public, we will specifically design adapted communication material to support the dissemination of NIMFEIA. This includes setting up online communication resources like press releases on project advancements written in English language but also in the mother languages at the partners' institutions and the NIMFEIA website. The HZDR partner possesses extensive experience in producing 3D computer graphics with strong visual aesthetics which will be invaluable for creating memorable visual elements and easy-to-follow explanations of the underlying physic for the general public.

HZDR hires professional science journalists to craft press releases. This way, generating public awareness of NIMEIA's research results has proven quite successful: One of our main achievements, the application of a magnon reservoir for pattern detection, was reported in the *Frankfurter Allgemeine Sonntagszeitung* and in the Computer-magazine *c't*. These publications triggered an invitation to write a scholarly article on „AI and magnon reservoir computing“ for the magazine *Physik in unserer Zeit*, which is in preparation and scheduled for publication in fall 2025.

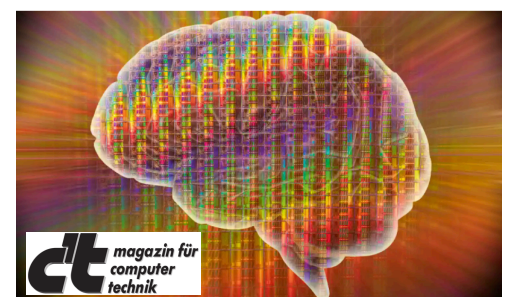
Furthermore, the NIMFEIA partners will promote their research activities by participating in open days and other events such as Mainz Science Market, Dresden Long Night of Science, Pint of Science, Science week festival, European Researchers' Night, Nanoscience for pupils, etc.

#### 2.1.1. Science fair organized by the partner JGU

The *Mainz Science Alliance* is network of local universities,



Article in one of Germany's largest newspapers on NIMFEIA's recent results. The article was triggered by a press release from HZDR.



### Magnetwellen-KI

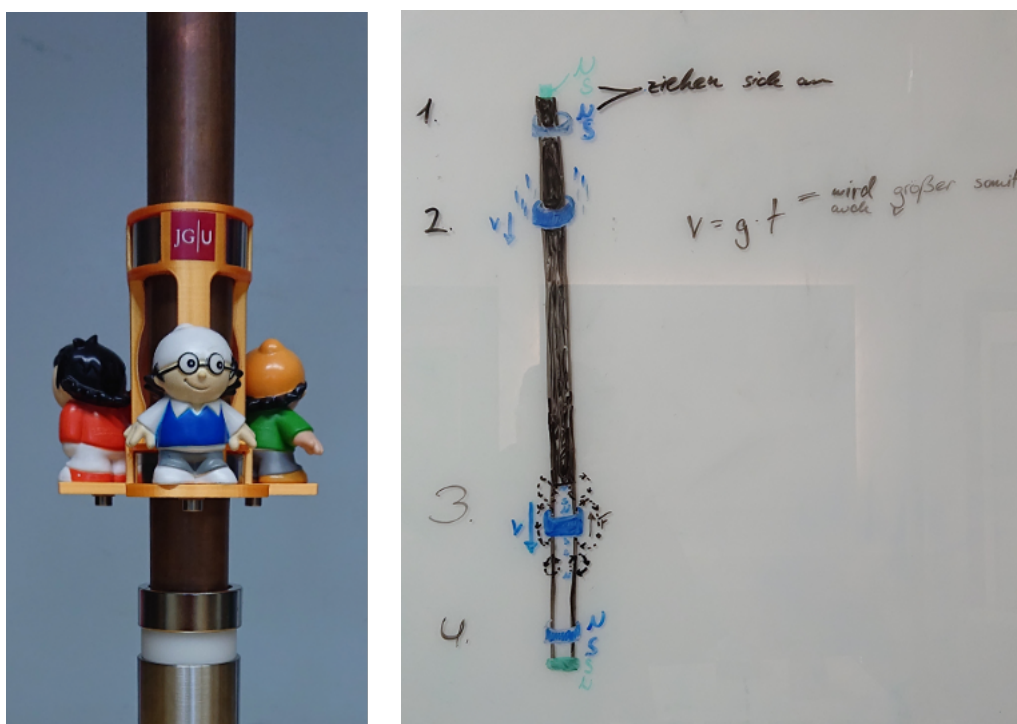
Neuartige Chiptechnik erkennt Muster in schnellen Sensordaten

Forscher am Helmholtz-Zentrum in Dresden entwickeln eine künstliche Intelligenz, die mit Magnetwellen auf Mikrochips rechnet. Im Projekt mit Halbleiterherstellern wollen sie daraus schnelle KI-Systeme zum Beispiel für autonome Autos zur Industriereife bringen.

Article on NIMFEIA results in the Computer-Magazine *c't*.



research institutes and companies. Their goal is to expand cooperation between business and science and to create a fertile environment for new ideas and innovative products. The *Science Market* of the *Mainz Science Alliance* took place on September 7th and 8th, 2024 and brought science to life on the Gutenberg Square, right in the center of Mainz city. With enormous involvement and fresh ideas, passionate members of the NIMFEIA partner JGU presented their research on magnetism to the general audience. In this way, they encouraged those small and big, young and old to take part in the little as well as large wonders of science. Due to the more general audience, mainly experiments that could visualize magnetism, and its effects were presented and interested public was informed on details of research. One highlight was the free fall tower, as shown in the figure below, a fun experiment highlighting the fundamentals of magnetism and eddy currents to ensure 100% fail safe breaking. Therefore, a demonstrator was designed and built which could be operated by the guests themselves.



Left: Photo of the free fall tower designed and built by the partner JGU with carousel in end position levitating over permanent magnet. Right: Explanation of free fall tower as sketched from pupils doing a lab course on magnetism with the partner JGU.

### 2.1.2. Outreach to pupils by the partner JGU

The partner JGU regularly hosts pupils with interest in natural sciences for internships. The pupils are most often shortly before finishing school and are motivated to explore if scientific research is an option for them. To maintain Europe's competitiveness, it is of utmost importance that we especially motivate young women to study natural sciences. In January 2025, three female high school scholars participated in the lab course at JGU. At the end, they produced an explanation video for the free fall tower experiment mentioned above on their own. Additionally, it is important that pupils do not lose interest in MINT subjects before even entering high school. Therefore, it is necessary to motivate young kids by showing them how interesting science can be. In that respect, Prof. Kläui gave a special lecture at a primary school in Mainz on 12th of March 2025. The topic was the use of magnetism and superconductivity. The pupils were super excited about this presentation. Due to privacy restrictions, we cannot



show the respective images here. Of course, the content of a presentation targeting this group cannot address NIMFEIA's activities directly but only the broader background of magnetism.



Motivational slide for magnetism education generated within NIMFEIA.

### 2.1.3. Day of the open lab by the partner HZDR

As part of our outreach activities, the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) regularly organizes a public Day of the Open Lab. We invite visitors to experience science up close and engage with our researchers. Guests can take part in guided tours through large-scale facilities and laboratories. They can explore cutting-edge research in energy-efficient electronics, superconductors, and high-field magnets. Other highlights include particle accelerators, laser systems, astro-particle physics, and cancer therapy research. We also present novel materials for memory and computing technologies. A special focus is placed on student engagement, offering information on internships and career opportunities. Young visitors can enjoy hands-on activities and interactive experiments. The event is designed to inspire curiosity and foster dialogue between science and society. It's a day of discovery, learning, and fun for all generations. The NIMFEIA members at HZDR organize special activities related to tunneling magneto-resistance (TMR) and MRAM devices from GlobalFoundries. In talks specifically addressing the general public, we introduce the hardware history of artificial intelligence and today's approaches for AI. We aim to increase public awareness of the sustainability challenges of state-of-the-art technology and how research results of the NIMFEIA consortium can make an impact in this field.

### 2.2. BSc and MSc students and Ph.D. students

Young students are the foundation of Europe's future. We aim to wake interest in scientific studies in general, and for the research activities of the NIMFEIA project specifically, to prepare them for the future European knowledge-based ICT society. We will promote the research and its results at open days, national science days, and regional initiatives to promote the communication of science to society. For Ph.D. students trained in the NIMFEIA project, we will promote their attendance at (inter)national conferences and summer schools, such as those organized yearly by the IEEE Magnetics Society or the European Magnetism Association, to foster knowledge and curiosity beyond their specific research topic. Furthermore, partners of the NIMFEIA consortium will organize extended exchange visits for their students.

### 2.3. Academia

NIMFEIA builds on a lot of preceding fundamental research which is now transformed into a revolutionary concept shifting paradigms in reservoir computing towards operating in recipro-



cal space. Hence, we anticipate that the NIMFEIA project will generate scientific results warranting publication in high-impact journals including, but not limited to, Nature family journals, Science, Physical Review Letters, Nano Letters, Physical Review B, etc. Preference will be given to gold open-access journals. Particular attention will be paid to offering development perspectives that shall stimulate research and build bridges between different communities.

We expect the results of the NIMFEIA project to generate large interest not only in the communities of spintronics and magnonics but also beyond. This will allow us to disseminate our work to a broad audience via contributed and invited talks. As a result of the Corona pandemic, there has been a shift towards organizing conferences and workshops online or in a hybrid format which allows scientists from around the world to gather more easily. Still, we believe that scientific advancement thrives from personal face-to-face discussions so members of the NIMFEIA consortium will try to find a balanced mix between online and in-person participation in (inter)national conferences and workshops, such as Material Research Society (MRS) conferences, March Meetings from the American and German Physical Society, Magnetism and Magnetic Materials (MMM), Joint European Magnetic Symposia (JEMS), Magnonics Workshop, IEEE Intermag, International Green and Sustainable Computing Conference (IGSC), International Conference on Artificial Neural Networks (ICANN), International Electron Devices Meeting (IEDM), etc.

In order to explore synergies with other EU-funded projects, as part of the HOP-ON initiative, a symposium will be sponsored by the NIMFEIA project where 10 EU-funded projects will be hosted at INL in May 2024 to facilitate the dissemination of the project results and to encourage networking for future proposals.

Towards the end of the project, the NIMFEIA partners will organize a 3-day international scientific workshop bringing together major actors in the fields of or adjacent to spintronics and magnonics as well as researchers involved in photonic reservoir computing. This workshop will gather around 20 invited speakers and will promote the research undertaken in NIMFEIA to the scientific community across various disciplines.

## 2.4. Industry

Part of our communication strategy will focus on industry and the communities outside spintronics and magnonics. The overall process followed towards the development of the industrial communication strategy will be to (i) consider the target audiences related to their market segments and special needs; (ii) ensure that the message is clearly defined and addresses the needs of each target audience; (iii) select/fine-tune the communication activities. Besides taking advantage of the extensive network provided by our two industrial partners, we will actively participate in industry exhibitions and fairs on a national and international level. Furthermore, we aim to approach the industry, especially locally operating SMEs, directly in their mother tongue. Our proposed concept of reservoir computing in reciprocal space and the idea of making devices larger instead of smaller is so fundamentally different from existing technologies that direct communication to the industry is paramount for our technology to become successful.

### 2.4.1. XMR-Symposium: Magnetoresistive Sensors and Magnetic Systems

Magnetic sensors and magnetic systems are technologies in which European industry is competitive worldwide and often leading. In contrast to CPU and GPU production, which requires latest semiconductor technology with smallest feature sizes, and fabs that costs billions of Euros, magnetic sensor systems require less processing power. Instead, detailed knowledge of



the magnetic system and tailoring to the needs of the specific requirements of the application are more important. This calls for interactions between research, industry development and customers. The company *Sensitec* is one of the biggest producers of magnetic sensors in Europe. To foster exchange, they organize biyearly symposia on magnetoresistive sensors and magnetic systems. More than one hundred experts, mainly from industry and research institutes, gather for two days to discuss in focussed sessions including the entire plenum. The experts present were mainly senior technology developers of the respective companies.

The research ideas of NIMFEIA were addressed in two contributions by the partner JGU. Prof. Gerhard Jakob gave an invited talk on ‘New directions, mechanisms and materials in magnetoresistive technology’ with the research of NIMFEIA playing an important role. Especially the unconventional computing ideas addressed by the NIMFEIA consortium formed an essential topic of this presentation. A second contribution was given by Prof. Kläui in form of a poster on ‘Skyrmion Based Sensor Devices’. Therein, skyrmion devices and the general concept of reservoir computing using nonlinear magnon interactions in reciprocal space were presented. At this poster intense discussions with interested engineers from industry took place, as the introduced concept was new for them.

### 3. Exploitation activities

Innovation management is key to bringing NIMFEIA’s technology to the market. With an active innovation strategy, we aim to protect any valuable innovations while at the same time striving to publish all scientific results openly. To achieve both of these goals, the key issue is timing and discovering innovations that should be considered for further development at an early stage. This allows for securing intellectual property rights (IPR) early on. For that purpose, the NIMFEIA consortium will be supported by the HZDR Innovation GmbH which was launched in 2011 by NIMFEIA’s coordinating institution HZDR with the aim of nourishing innovation in science and transferring novel technologies to industry. As a spin-off, it realizes commercial production of research innovation prototypes and manages industry contacts for the commercial use of scientific large-scale facilities. The HZDR Innovation GmbH supports the transfer of research results and their transformation into successful start-up companies. Dedicated funding schemes such as the Helmholtz Enterprise program support scientists to work entrepreneurial and start a well-thought-out business.

During the NIMFEIA project, early identification of innovations will be targeted at consortium meetings. The Dissemination and Exploitation Committee (DEC) will monitor the project for innovations, providing advice and guidance in innovation management and intellectual property rights. The DEC will aim to assess the potential of inventions for applications, support technology transfer, and develop systematic exploitation strategies. In the case of joint inventions which arise from the cooperative research of all NIMFEIA partners, the joint filing of patents is encouraged. Each work package leader will be responsible for identifying potential inventions and reporting them to the DEC. The subsequent evaluation of the idea and market research will be performed by the DEC supported by local technology transfer executive offices of the partners. The DEC will take care of timely IP protection.

In particular for the definition of realistic use cases for magnon reservoirs, we organize recurrent meetings with members of our associate industry partner Infineon. We discuss the newest results on the magnon reservoir performance, increased complexity and frequency range and elaborate on potential use-cases that fit the specifications of the extended parameter range. Furthermore, we aim to exploit magnon reservoirs in collaboration with Infineon’s



quantum computing department in Dresden. On March 6th, 2025, during a one day Workshop at HZDR, members from the NIMFEIA consortium discussed with Dr. Wolfram Langheinrich and his team Infineon’s activities quantum computing and how NIMFEIA’s technology can be implemented as an interface between standard electronics and qubit programming lines. Dr. Langheinrich suggested to establish a recurrent meeting between local industry and science partners working in the fields of quantum technology and applied magnetic phenomena. The NIMFEIA members at HZDR agreed to organize the first kick-off meeting in late 2025.

#### 4. Overview of dissemination and exploitation activities

The following table summarizes the dissemination and exploitation activities of the NIMFEIA project.

Target group	Goals	Actions	Timeframe
General Public	<ul style="list-style-type: none"> <li>• Create awareness of the aims of NIMFEIA</li> <li>• Create awareness of breakthroughs</li> <li>• Create awareness of progress in digitization and its impact on energy consumption</li> </ul>	<ul style="list-style-type: none"> <li>• Sharing news on website</li> <li>• Public lectures festivals</li> <li>• Visibility in Newspapers</li> <li>• Press releases on partner’s website in English and mother tongue</li> <li>• Promotional videos</li> </ul>	Monthly 1-2/year 1-2/year 1-2/year
Primary/ High School students	<ul style="list-style-type: none"> <li>• Stimulate children and students for science</li> <li>• Inspire students for physics of magnetism</li> </ul>	<ul style="list-style-type: none"> <li>• Magic-of-magnetism experiments at high schools</li> <li>• Lectures at open days</li> <li>• Lecture Pre-University College</li> </ul>	Yearly Yearly Yearly
BSc and MSc students	<ul style="list-style-type: none"> <li>• Education in aims of NIMFEIA</li> <li>• Practise presentation of results</li> <li>• Education in working on innovations</li> </ul>	<ul style="list-style-type: none"> <li>• Lectures at master courses</li> <li>• Discussion meetings</li> <li>• Group seminars</li> <li>• Arrange internships in industry</li> <li>• Stimulate mixed career paths</li> <li>• Promote attendance of summer schools</li> <li>• Arrange extended exchange visits of students at partner institutions</li> </ul>	1-2/year Weekly Weekly 1/year
Academia	<ul style="list-style-type: none"> <li>• Share research outcomes</li> <li>• Trigger external input for NIMFEIA</li> <li>• Stimulate experimental verification</li> </ul>	<ul style="list-style-type: none"> <li>• Publications</li> <li>• Talks at (inter)national conferences and workshops</li> <li>• Organization of workshops and seminars</li> <li>• Joint research bridging theory and experiment</li> </ul>	3-5/year >10/year



Target group	Goals	Actions	Timeframe
Industry	<ul style="list-style-type: none"> <li>• Stimulate exploitation of reciprocal space computing</li> <li>• Disseminate open source software</li> <li>• Stimulate application discoveries</li> <li>• Protect intellectual properties</li> </ul>	<ul style="list-style-type: none"> <li>• Industry exhibitions and fairs</li> <li>• Organize workshops and outreach events at partner facilities</li> <li>• Promote internships</li> <li>• Collaborative proposals (EU-EIC, NWO-Industrial Partners Program, BMBF)</li> <li>• DEC meetings</li> <li>• Patent filing</li> </ul>	(Bi)annual (Bi)annual Yearly Yearly

