



Fibre Optic Nonlinear Technologies [FONTE] - A European Industrial Doctorate [GA766115]

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Consortium



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Executive Summary

FONTE beneficiaries **TU Delft** and **Aston University**, together with the **Delft Center for Systems and Control (DCSC)** at the Technical University of Delft, Netherlands, organised the third FONTE Open-To-All Workshop and symposium. The free event focussed on both theory and applications of **Nonlinear Fourier Transform (NFT)** and concluded with a hands-on practical session working with **NFT software** developed by FONTE beneficiary TU Delft.

The two-day **2020 NFT Workshop and symposium** was delivered by prominent members of the FONTE consortium and their research groups: Assoc **Prof S Wahls**, Dr **M.Bruehl**, **S. Chimmalgi**, (all TU Delft); Dr **V. Aref** (Nokia Bell Labs); Prof. **Y. Jaouen** (Telecom Paris), Dr **M. Kamalian-Kopae** (Aston University). Additional *external* high-profile speakers, include **Prof S Randoux** (Universite de Lille), **Prof G El** (Northumbria Univ) and **Prof P Suret** (Universite de Lille).

Publicised widely via a dedicated website and social media, the workshop attracted 34 registrations from 14 universities and institutions and was delivered on 4-5th February 2020 at the Technical University of Delft, Netherlands.

All FONTE ESRs attended the workshop and symposium.



Figure 1: Participants of the 2020 NFT Workshop and symposium

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LIST OF ACRONYMS

| | |
|---------|--|
| AiPT | Aston Institute Of Photonic Technologies |
| EC | European Commission |
| EID | European Industrial Doctorates |
| ESR/ECR | Early Stage Researcher/Early Career Researcher |
| ITN | Innovative Training Network |
| FONTE | Fibre Optic Nonlinear Technologies |
| OTAW | Open-to-all Workshop |

1 NONLINEAR FOURIER TRANSFORM WORKSHOP AT TU DELFT, NL

On 4-5 February 2020, Project FONTE together with the Delft Center for Systems and Control (DCSC) at the Technical University of Delft, Netherlands Project FONTE organized a FREE 2-day workshop in Nonlinear Fourier Transform (**2020 NFT workshop and symposium**). The event brought together leading researchers in the fields of *optical transmission systems and nonlinearity mitigation, optical signal processing, information theory, nonlinear dynamics and telecommunications*.

The first day of the 2-day workshop not only introduced the participants to both *theoretical* and *computational* aspects of Nonlinear Fourier Transforms (NFTs) but also discussed their application in diverse fields such as *optical communications and analysis of water waves*.

The second day provided participants a chance to present their own, not necessarily NFT-related, research. At a final session, participants were able to engage with software to compute NFTs in hands-on sessions, with experts from DCSC at hand to assist with installing the software and running first examples on participants' laptops.

Attracting 34 participants from 14 higher education institutions from Europe and China, this FREE and open to all workshop aimed to educate PhD students and early career researchers.



1. WEBSITE AND REGISTRATION



Figure2: The workshop website landing page with registration link

Early on a dedicated website was created, containing all the expected information, i.e. sections about the scope of the workshop, schedule, detailed bios of the invited speakers and local information about the venue and travel. Most importantly the landing page of the website displayed a registration and communication link, leading to a Contact Form, thus automating the process of record keeping and maintaining contact with participants.

Figure 3: Contact Form for registration and communication with participants:

Through the Contact Form participants were also invited to submit an abstract of their own NFT-related research for consideration as a presentation during the workshop. Several of the suggested presentations were included in Session 3 of the workshop, therefore allowing participants to showcase their most recent results.

2 DISSEMINATION OF THE 2020 NFT WORKSHOP

A link to the NFT workshop website was temporarily placed on the FONTE Website, as well as several websites of affiliated projects (EID REAL-NET GA813114; EID MOCCA GA814147; ETN WON GA 814276). In addition, the 2020 NFT workshop and symposium was widely advertised through personal contacts, mailing lists, LinkedIn and social media, such as Twitter, where the information was extensively re-tweeted.



Figure 4: Dissemination of the workshop via website; Tweets and retweets on social media

Nonlinear Fourier Transform is a fairly narrow and niche research area. Nevertheless, the extensive effort to disseminate the 2020 NFT Workshop within a research community attracted 34 registrations from 14 higher education institutions in 6 European countries (UK, Netherlands, Denmark, Switzerland, France, Germany) and even further afield from China. Two-thirds (23) of the attendees were master and doctoral students, thus fulfilling the central premise of the Open-to-all Workshop being an educational forum for researchers in the early stages of their careers.

The success of the dissemination effort is also evidenced by the fact that several high-calibre leading research scientists opted to accompany their own post-doctoral and doctoral students to the 2-day event.



Figure 5: Origin of the registered participants of the NFT Workshop.

3 SPEAKERS, ABSTRACTS AND BIOGRAPHIES

High calibre invited speakers were confirmed and included prominent members of the FONTE's consortium: Assoc. **Prof. Sander Wahls** (WP2 Leader; Workshop Co-Organiser; opening address and keynote speaker; TU Delft), **Prof. Yves Jaouen**, (WP4 Co-supervisor; Telecom ParisTech), **Dr. Vahid Aref** (Supervisor; Nokia Bell Labs), in addition to invited speakers affiliated with FONTE beneficiaries: **Dr Srikanth Sugavanam**; **Dr. Morteza Kamalian-Kopae** (both Aston University), **Dr. Markus Bruehl** and **Mr. Shrinivas Chimmalgi** (both TU Delft).

Notably, additional prominent speakers from *outside* the FONTE consortium accepted invitations to present at the open-to-all workshop and symposium: **Prof S Randoux** (Universite de Lille), **Prof G El** (Northumbria Univ) and **Prof P Suret** (Universite de Lille).

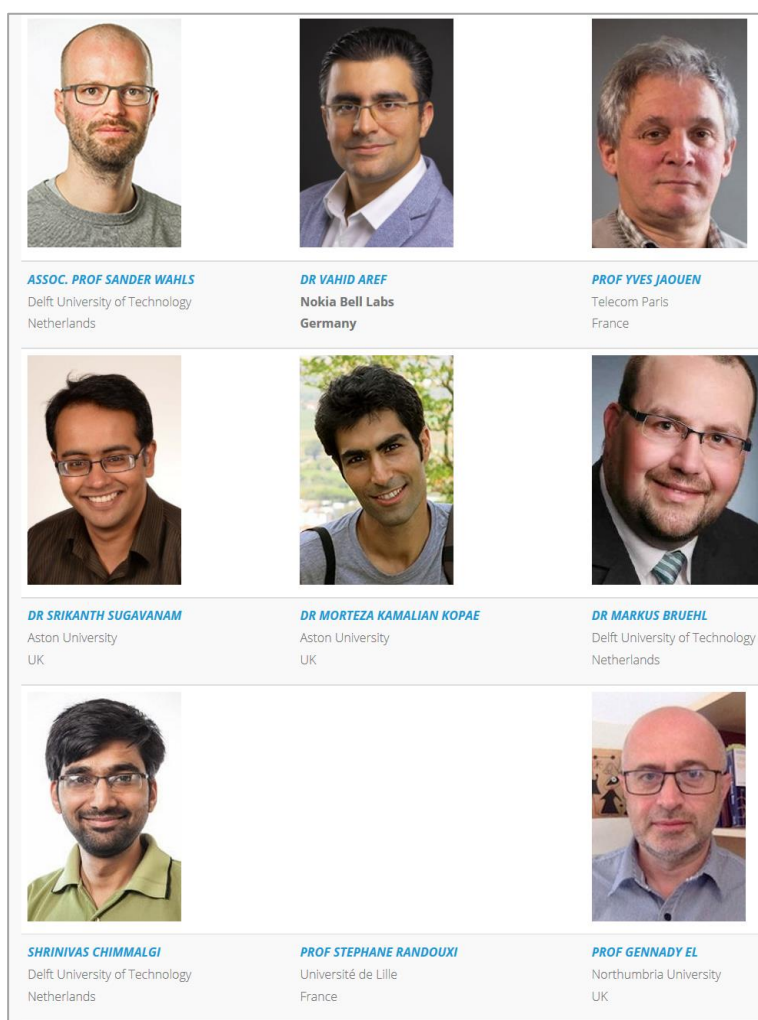



Figure 6: Invited speakers of the NFT Workshop and symposium

One session of the 2020 NFT workshop and symposium (session 3) was reserved for talks submitted to the organisers by registered participants, given a forum to young scientists to showcase their research. **FONTE ESR2, Vinod Bajaj (TU Delft)**, was among this group and presented his most recent findings during the workshop.

All invited speaker, abstracts of their talks as well as their biographies were available on the website of the NFT-Workshop

[NFT-Workshop 2020](#)
[Schedule](#)
[Venue](#)
[Register](#)
[NFT Workshop Organisers](#)
[Images](#)

Howdy, christiane



Short bio

Morteza Kamalian-Kopae received his BSc in electrical engineering from Isfahan University of Technology, Isfahan, Iran, his MSc in communication engineering from Yazd University, Yazd, Iran, and his PhD in electrical engineering from Aston University, Birmingham, UK. Since graduation, he has been with Aston Institute of Photonic Technologies (AIPt) as a research fellow working on nonlinear Fourier transform, in particular, for periodic solutions of the nonlinear Schrödinger equation. His research interests include **signal processing** in optical communication, **analysis of nonlinear dynamics**, and wireless communication systems.

Talk Title

NFT FOR LASER CHARACTERIZATION

Abstract

Modern high-power lasers exhibit a rich diversity of **nonlinear dynamics**, often featuring nontrivial co-existence of **linear dispersive waves and coherent structures**. While the classical Fourier method adequately describes extended dispersive waves, the analysis of time-localised and/or non-stationary signals call for more nuanced approaches. Yet, mathematical approaches that can be used for simultaneous characterisation of localized and extended fields are not yet well developed. Here, we demonstrate how the **nonlinear Fourier transform (NFT)** based on the **Zakharov-Shabat spectral** problem can be applied as a signal processing tool for representation and analysis of coherent structures embedded into dispersive radiation. We use full-field, real-time experimental measurements of mode-locked pulses to compute the nonlinear pulse spectra. For the classification of lasing regimes, we present the concept of eigenvalue probability distribution. We present two field normalisation approaches and show the NFT can yield an effective model of the laser radiation under appropriate normalisation conditions.

Theme by Tesseract

Figure 7: Example of a Speaker's Biography and Talk Abstract

4 HANDS-ON NFT SOFTWARE

Uniquely, the 2020 NFT workshop and symposium included a hands-on session for participants to engage with software to compute NTFs, developed by Assoc Prof Sander Wahls and his group at TU Delft. After a short talk introducing the software, experts from TU Delft were at hand to assist with installing the software and running first examples on participants' laptops.



Figure 8: Participants running first examples of the NFT software during the workshop

5 COMPLETE SCHEDULE OF TALKS

The 2-day event covered an ambitious schedule of fourteen talks.

A full list of talks at the FONTE's 2 day *Open-to-all 2020 Nonlinear Fourier workshop and symposium* is detailed below:

NFT-workshop Day 1, 04 February 2020

Delft University of Technology (TU Delft); **Pulse Building**; Hall 5

(Scroll Down for Day 2)

Session 1: Introduction to the NFT and its computation

0900-0915 **Opening remarks**

ASSOC. PROF SANDER WAHLS

Delft Center for Systems & Control

Delft University of Technology, Netherlands

0900-1000 **Introduction to NFT**

ASSOC. PROF SANDER WAHLS

Delft Center for Systems & Control

Delft University of Technology, Netherlands

1000-1015 Coffee Break

1015-1100 **Numerical computation of NFTs** Abstract

SHRINIVAS CHIMMALGI

Delft Center for Systems & Control

Delft University of Technology, Netherlands

1100-1115 Break

1115-1200 **Periodic NFT and its application in optical communications** Abstract

DR MORTEZA KAMALIAN-KOPAE

Aston Institute of Photonic Technologies

Aston University, UK

| Session 2: Applications of the NFT | |
|------------------------------------|--|
| 1400-1425 | <i>Dual polarization NFD systems: From theory to experiments</i> PROF YVES JAOUEN Communications and Electronics Department Telecom Paris, France |
| 1425-1450 | <i>Three Different NFT Algorithms for Discrete Spectrum</i> DR VAHID AREF Nokia Bell Labs Germany |
| 1450-1505 | Coffee Break |
| 1505-1550 | <i>Recent results about nonlinear spectral analysis in optical fiber and in hydrodynamic experiments</i> PROF STEPHANE RANDOUX Université de Lille France |
| 1550-1605 | Break |
| 1605-1650 | <i>NFT for shallow water wave data</i> Abstract DR MARKUS BRUEHL Delft Center for Systems & Control Delft University of Technology, Netherlands |
| 16:50-17:00 | Photo of conference participant |
| 0 | Venue: TU Delft sign at 52°00'05.9"N 4°22'21.4"E |
| 1900 | Dinner and networking opportunity De Kurk Restaurant Kromstraat 20, 2611 ER Delft, Netherlands |

NFT-workshop Day 2, 05 February 2020

Delft University of Technology (TU Delft); **Pulse Building; Hall 5**

| Session 3: Contributed talks by participants | |
|--|---|
| 0900-0945 | <i>Spectral theory of soliton and breather gas for the focusing NLS equation</i> PROF GENNADY EL Department of Mathematics Northumbria University, UK |
| 0945-1005 | <i>Bound State Soliton Gas Dynamics Underlying the Spontaneous Modulational Instabilitys</i> Abstract PROF PIERRE SURET Universite de Lille, France |
| 1005-1020 | Coffee Break |
| 1020-1040 | <i>Exact NFDm Transmission in the Presence of Fiber-Loss.</i> Abstract VINOD BAJAJ, MSc Early Stage reasearcher in project FONTE – EID TU Delft (Delft, Netherlands) and Nokia Bell Labs, Germany |
| 1040-1100 | <i>Impact of Linear WDM Soliton Superposition on the NFT-Spectrum</i> Abstract JONAS KOCH, MSc Christian-Albrechts-Universität zu Kiel, Germany |
| 1100-1115 | Break |
| 1115-1135 | <i>Joint Detection Equalization on Nonlinear Fourier Transform based optical Communication</i> Abstract KEN CHAN, MSc Helmut-Schmidt-Universität, Hamburg, Germany |
| 1135-1155 | <i>Nonlinear spectral synthesis of breather gas in focusing NLS equation: a numerical approach</i> Abstract GIACOMO ROBERTI, MSc Northumbria University, UK |
| Session 4: Hands-on session | |
| 1400-1600 | <i>Hands-on session on using software to compute NFTs</i> Short talks introducing the software, participants bring their laptops and are helped with installing / running first examples. (SANDER WAHLS & SHRINIVAS CHIMMALGI) |

Figure 9: Schedule of the 2020 NFT Workshop and symposium



6 SOCIAL MEDIA INTERACTION DURING OTAW

FONTE and NFT workshop organisers tweeted extensively during the Open to all workshop and symposium, generating interest in both the FONTE-EID project (translating into new followers on this platform) and the NFT workshop in general, with numerous retweets and 'likes' of FONTE's twitter feed:

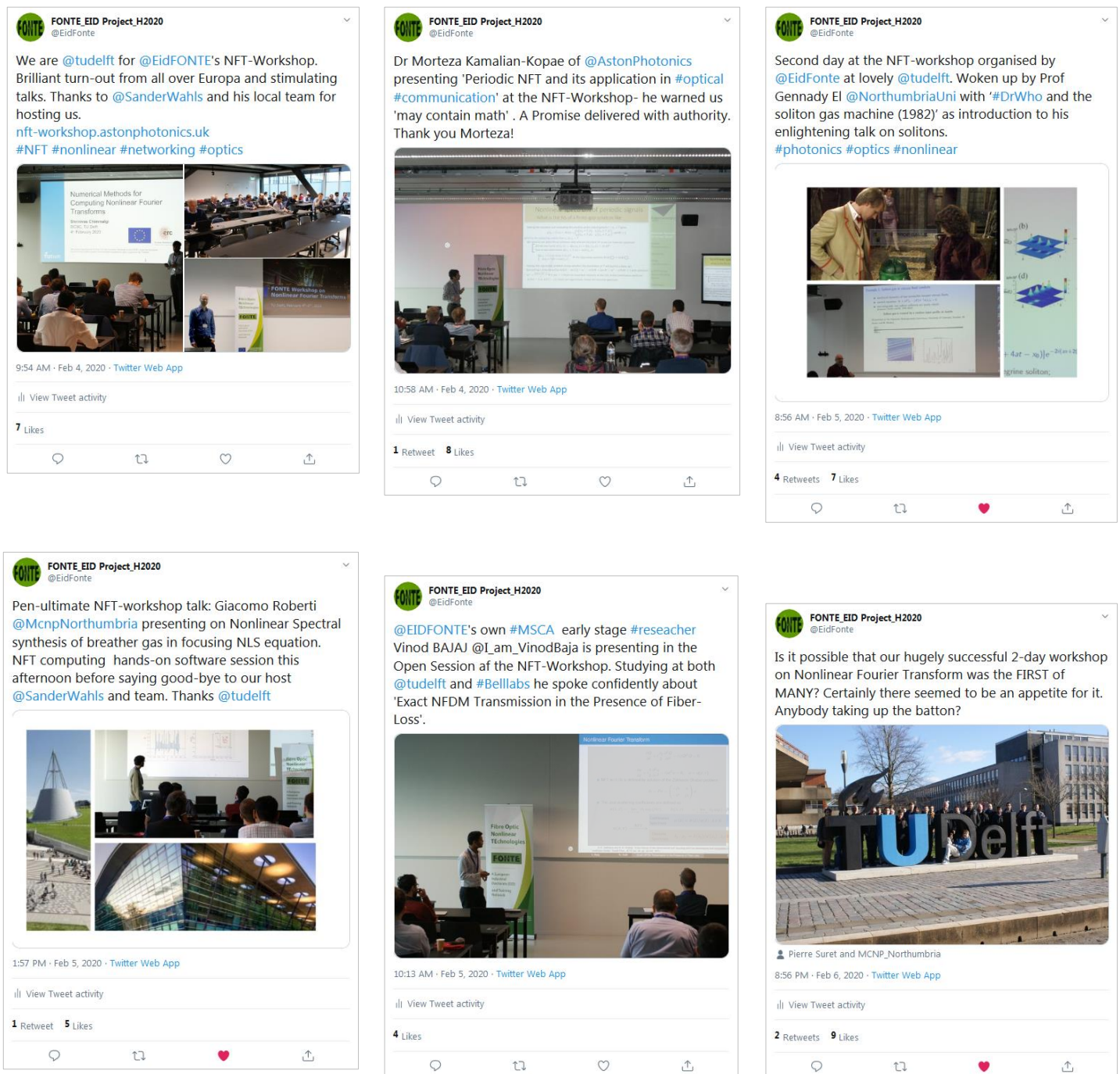


Figure 11: Social media feed during OTAW and symposium

7 POST-EVENT ACTIVITIES

Presentations were collected from all participants and made available **confidentially** to workshop participants via a dedicated, time-limited download link, thus completing the OTA workshop's aim to educate early career scientists and foster an exchange of ideas, as well as creating conditions in which collaborations between workshop participants can flourish.

The success of this unique 2020 Nonlinear Fourier Transform workshop is also exemplified by the fact that currently the organisers are considering to organise a follow-up workshop in 2021.



Figure 12: During the NFT Workshop and symposium