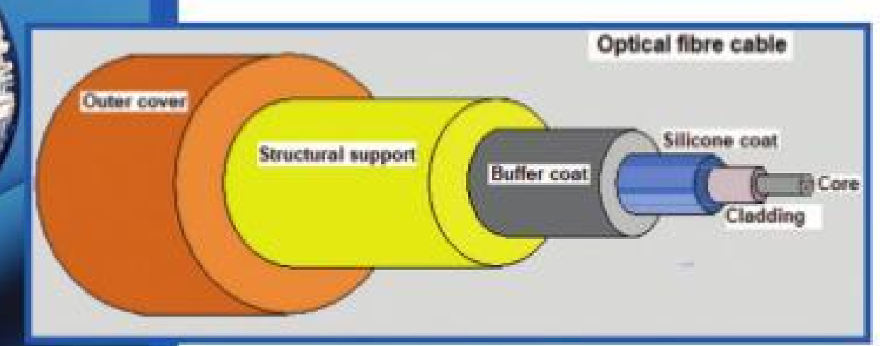
Flattening barriers in telecom

Innovations in the optical fibre may turn the data stream into a data flood



Gas molecules form a pattern of clumps when the signal and the external source interact

S ANANTHANARAYANAN

The Internet has changed the world beyond recognition. And this is thanks to new channels of worldwide communication – which became possible when electrical signals were replaced by light, and copper wires by filaments of glass – the optical fibre cable.

Luc Thévenaz, with Fan Yang?and Flavien Gyger, from the Ecole Polytechnique Fédérale de Lausanne, in Switzerland, report a way around what is considered a limitation and further increase the reach of the optical fibre. Writing in the journal, *Nature Photonics*, they describe how the *Hollow Core Fibre* where the glass in the fibre is replaced by any gas, can be made to work better, and in more ways, than the solid glass fibre.

The conventional optical fibre cable is a narrow, literally less than a hair's breadth, thread of glass -- contained in protective sheathing -- that transmits rays of light. The light rays strike the sides of the narrow glass channel at glancing angles and stay within the cable, for hundreds of kilometres, with negligible loss. As the speed of light in glass is not the same for all colours, however, an ordinary light ray would get split into its component colours. The light ray hence has to be accurately of a single colour, and hence has to be a laser beam. The laser also ensures that the beam is narrow and stays compact in its passage through the cable.

Although the loss of signal strength is low, after a distance, there does come a point where the beam strength needs to be refreshed. One way to do this is to read the signal and then generate a fresh, full strength signal. What is done, however, is to refresh the signal within the cable, by building in a laser action that is activated by the original, but enfeebled beam. This amounts to building into the optical fibre the same mechanism that generated the original beam, which has now become feeble.

A laser works with the help trace impurities that are added, and which absorb the energy of a source of light, and store the energy for a short time, for release in tandem with pulses of light that stimulate emission. If this process repeats within a resonating cavity, energy can build up, for release as a beam of light that is intense, and, in addition, with the photons all in the same phase of oscillation, because of the manner of their creation. In the glass filament of the optical fibre also, a trace impurity is introduced, of atoms that absorb photons from an external source of energy and then, on stimulation by photons of the enfeebled laser light, release the stored energy with greater intensity.

One of the reasons that a beam gets weakened while passing through the fibre is that it gets scattered. There could be just random scattering, which is the same light in all directions, or there could be scattering where photons of light gain energy from the scattering centres, or give up some energy. In these cases, the colour of the scattered light gets modified.

And yet another way is where the electric vibrations of the light waves, of the signal and the external source, set up periodic movements, and hence changes in the optical properties of the material of the fibre. When this third kind takes place, the much lower speeds of mechanical waves, compared to light waves, results in the wavelengths being of similar dimensions and there is interference. This can give rise to a reflected, or reverse propagating optical wave, and by selecting the frequency of the external source, there can be transfer of energy to the signal wave.

This kind of scattering, which the signal beam itself gives rise to, is called *Stimulated Brillouin Scattering*, named after Léon Brillouin, who in 1922, predicted scattering by density variations in materials. This kind of scattering can influence the working of the fibre channel and is a reason that the amplification of the signal in optical fibre needs to be regulated.


Luc Thevenaz

The Hollow Core Fibre

Such limitations and possibilities apart, there is always the desire to increase the distance that a light beam can travel before it needs to be amplified. One way is to use a hollow glass filament, in place of a solid one. Light then travels through the gas in the hollow cavity, and is scattered a lot less than when it travels through glass.

While this is a great advantage, there is a down side – finally, when the beam does need to be amplified, the use of a gas does not offer us the solutions that we have with a solid material like glass. This is where the work of Thévenaz and his colleagues comes in to overcome the obstacle, to "square the circle," as Thévenaz puts it.

The main obstacle is that gasses have little mass, compared to solids, and are not able to interact substantially with optical waves. In trials with atmospheric air, the Brillouin amplification was found to be 1,000 times feebler than with a solid silica (glass) core, the paper says. The way the Lausanne team attacked the challenge is to fill the hollow cavity with carbon dioxide gas at a pressure of 41 bar or 41 times the atmospheric pressure. The light beam has the same, low scattering, long range, even at high pressure, but thanks to the pressure, the action of the signal and the external light source (the "pump" and the "probe") is to get the gas molecules to form periodic lumps.

This periodic clumping together of matter, with a distribution comparable with the wavelength of the light, affects the interaction of the light waves in a manner similar to what happens in the solid fibre. And there is transfer of energy from the external source to the signal – which is amplification – six times more than with glass-filled fibres, the paper says. The "circle is hence squared", the advantages of using gases, these include being able to withstand high intensity and being transparent to frequencies from the infrared to ultraviolet, are all there, and now we have amplification too.

"The idea had been going around my head for about 15 years," Thévenaz says in a press release. And with the work with colleagues in the EPFL lab at Lausanne, near Geneva, Thévenaz has brought in this new technology.

With evident value in improving communications with the use of optical fibre, gas filled cavities present other applications too. One such is to adapt the arrangement to work as a Brillouin laser. Another is in sensing temperature variation along the length of the fibre. When solid glass fibre is used, it is possible to detect changes in the Brillouin scattered radiation, because of temperature change, or physical deformation. This effect on underground optical fibre cables is being used to map earth tremors.

The changes in the scattering because of temperature changes, however, cannot be told apart from changes caused by strain or physical deformation. When the fibre is gas-filled, on the other hand, it is only the temperature that affects the speed of sound, or mechanical effects in the gas. A gas-filled optical fibre cable running through a tunnel could thus pinpoint a fire anywhere along its length!

The writer can be contacted at response@simplescience.in

PLUS POINTS

Managing waste

Researchers from the Indian Institute of Technology-Madras and Stuttgart University, Germany have developed "co-composting" methods that can be used to safely dispose of toxic pharmaceutical wastewater sludge. They have already established composting facilities in various villages across India based on their studies through which stabilised compost that meets international quality standards can be obtained within 20 days.

The team is also in discussion with the Government of India for setting up more such facilities for septage management. While the initial objective of the study was to understand how pharmaceuticals and personal care products affect the composting process, the results obtained in the study have opened up the avenue of use of "co-composting" to treat toxic wastewater sludge.

The research was led by Ligy Philip (*in photo*), department of civil engineering, IIT-Madras, and included Anu Rachel Thomas from IIT-Madras and Martin Kranert from the Germany-based Institute for Sanitary Engineering, Water Quality and Solid Waste Management, Stuttgart University. The paper was co-authored by Thomas and Kranet along with Philip. The results of the study have been published recently in the journal *Waste Management*.

Philip said, "Even though pharmaceuticals and personal care products are less susceptible to biodegradation, the addition of mixed organic waste and coir pith (bulking agent) during septage composting provided an appropriate conducive environment for significant carbamazepine removal. Therefore, in-vessel 'co-composting' of septage can be considered as a resource recovery option for septage treatment."

The chemical released from personal products and medicines is a major waste management challenge due to two issues,

- The chemicals are difficult to decompose and also affect the decomposition rate of the other organic waste in the septic tank.
- The untreated waste containing these chemicals damages, the flora and fauna of the aquatic bodies and fields where it is thrown. Studies have shown that 10-90 per cent of pharmaceuticals and personal care products are excreted in the parent form and rest in the conjugated form.

"With increasing population, the usage of onsite sanitation systems like septic tanks have been increasing every year, leading to the disposal of an enormous quantity of septage into the environment without proper treatment. Untreated septage disposal creates environmental degradation which includes contamination of precious surface and groundwater sources, serious health threats and potential greenhouse gas emissions," said Philip.

To understand this problem in greater detail, Phillip and her team carried out a study to understand the impact of pharmaceuticals and personal care products on the compost dynamics. Philip's laboratory has been working in the area of waste management and has also developed a treatment strategy based on "in-vessel co-composting" for septage management in septic tanks.

For this study, the team decided to determine the degradation pattern of Triclosan and carbamazepine. While triclosan is a commonly used antimicrobial compound in toothpaste, detergents and soap, among other products, carbamazepine is a widely used antiepileptic drug.

The researchers conducted experiments in an in-vessel composter where the dewatered septage collected from a sewer plant and mixed organic waste was used apart from the pollutants or in other words, triclosan and carbamazepine. The scientists tested three concentrations of the pollutants five, 50 and 100 mg per kg of dry weight either alone (triclosan/carbamazepine) or together (triclosan and carbamazepine). They tested various parameters of compost every day to understand the change in dynamics due to the pollutants.

The team found that at a lower concentration of five mg per kg of dry weight, carbamazepine degraded up to 83 per cent and triclosan up to 86 per cent. However, when both the pollutants were used, carbamazepine degraded up to 66 per cent and triclosan up to 83 per cent. Carbamazepine was found to have a more negative impact on compost dynamics as compared to triclosan and it was also observed that the higher concentration of these pollutants results in lower temperature which further leads to lower pollutant removal in the compost.

GROWING ARMY OF CITIZEN SCIENTISTS

The freely available trove of information online could help us better understand Covid-19, even if we are not experts

SUVODEEP MAZUMDAR

Imagine a world without the Internet, computers, smartphones, and easy access to information. Now, imagine a new unknown disease spreading like wildfire, leaving thousands dead every passing day. With lack of timely information and quick access to evolving advice, one can only imagine the fear, uncertainties and anxiety people would face.

The world that we live in now has changed rapidly since the days of the Spanish flu, just over a century ago. We now have access to information at our fingertips, real time streaming news, and can get customised notifications on any topic of our interest. We have the ability to generate vast amounts of information and release it to be consumed anywhere in the world. We, however, now find ourselves in a pandemic that is spreading across the globe at an unprecedented rate.

Thousands of lives have changed irrevocably, many loved ones have succumbed to the new virus and many have lost jobs and livelihood as the impact of Covid-19 shakes the very foundations of our societies. "Lockdown zones" and "lockdown days" are the new normal, and our social lives are increasingly "virtual". We wait in anticipation for any news of a possible end to the pandemic as we long for some potential cures and vaccines.

While our world changes around us, something fundamental has started to take shape under our very noses. We are now consuming scientific information and are exposed to scientific debates at a rate that one couldn't imagine a year ago. After months of following the news, many of us are now aware of scientific terminologies, processes of developing vaccines, the potential treatments to Covid-19, symptoms of the disease and so on. With an increased contextual awareness of Covid-19 and background understanding of the disease, we often find ourselves searching for and analysing specific information, in a sense, conducting our own research and investigations on the problems we find important. When this is done in a scientific and methodological manner, we see the start of a citizen science activity.

Citizen science is a highly evolving field of research, yet with a rich history going back many decades. Citizen scientists are ordinary citizens who typically volunteer their time and resources in conducting scientific research. There are many ways how citizen scientists can participate in research -- they can provide data as mere observers of certain phenomena (for example, cataloguing different types of birds and animals visible in their neighbourhoods) via crowdsourcing or offer their cognitive and visual perception abilities (for example, spotting the Vikram lander of the Chandrayaan 2 programme in images of the Moon).

A significant majority of citizen science research involves the collection of data from citizens via crowdsourcing, where research projects are already designed and managed by professional scientists. However, recent efforts in citizen science has focused on increasing the involvement of citizens in not only data collection but analysis and project organisation.

At the same time, data science has experienced a significant shift in the last few years where, in addition to accessing data free of charge, we now have the capability to process large amounts of data using sophisticated tools and algorithms, on the cloud, without the need for high performance computing resources or programming expertise. Learning data science can provide individuals with the knowledge to analyse real-world problems and often drive their own curiosity to study unique perspectives of day-to-day phenomena.

Citizen scientists now have the ability to conduct large scale experiments with near real-time data from all across the world and analyse a problem from a variety of perspectives. Equipped with this arsenal of tools for analysing complex problems, citizen scientists can now understand the current world and the growing pandemic in a manner that was hitherto unimaginable.

Enormous volumes of data are currently being released on Covid-19 by governments, organisations and health departments (like the Union ministry of health and family welfare, EU Open Data Portal, the UK Government's data.gov.uk, curated datasets in external platforms such as Kaggle, Worldometers) that are accessible in a variety of formats, free of charge. This has opened up enormous opportunities for citizen scientists to delve deep into such datasets, investigating new ideas. Analysing and processing the data using programming languages (such as Python, Java etc) and at the same time using standard libraries (such as Keras, Pytorch, Tensorflow etc) requires some understanding of data science, but with the wide range of free online tutorials available, this knowledge is easily accessible. At the same time, tools such as KNIME allow users to easily drag-and-drop machine learning models to develop machine learning workflows, without the need for writing a single line of code. Most cloud providers such as Google, Amazon, IBM and Microsoft also have a "free" subscription service where consumers can try out their cloud infrastructure and run small scale experiments.

With access to data and analyses, several tools and libraries are also available that enable the visualisation of complex data, each with varying degrees of technical requirements. For example, most programming/scripting environments like R, Python and Java have open source libraries that can help visualise data, while tools such as Tableau, Qlikview and KNIME provide simple drag-and-drop interfaces for visualising data. With the ability to analyse complex problems, citizens can also publish their results free of charge in a variety of social media and blogging sites, as well as platforms that are targeted towards programmers and developers such as Github. Most of these platforms allow others to contribute with their own views and opinions, thereby facilitating rich conversations around the analyses.

We are now at a point where we are not solely reliant on analyses and statistics presented to us by mainstream media – citizen scientists can now question narratives and interrogate analyses, explore new ideas and bring fresh perspectives into our understanding of evolving situations. With the power of social media, these can be shared widely to help others better understand the pandemic.

However, with these opportunities, we also open ourselves to immense risks – privacy, law and ethics are necessary to be questioned and debated when it comes to the application of data science. Serious questions have been raised around bias and transparency, where analyses using biased algorithms and datasets result in policies and decisions that are biased. At the same time, misinformation and disinformation campaigns often have the potential to sway public opinion and, at times of great uncertainty and public health risks, the application of data science in understanding such problems needs critical thought.

Nevertheless citizen scientists can bring in fresh perspectives by working together to solve great global challenges of our generation, albeit with the need for critical thought, discussions and debates.

The writer is a lecturer in data analytics, Information School, University of Sheffield, UK