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Science and the media

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ABSTRACT

Science seeks and needs the attention of the public and the media, and the media are eager for news from the world of research. This sometimes seduces scientists to communicate their results in early stages of their work and may bring them into the situation of the sorcerer's apprentice – they can't get rid of the ghosts they called. We give some recent examples of early or doubtful communication in physics and ask for a responsible cooperation of science and the media which takes care of the peculiarities of the scientific process.

Times of uncertainty are a normal part of the research process. It took from 1974 to 1978 till a handful of peculiar events in the MARK I experiment at the electron–positron storage ring Stanford Positron Electron Asymmetric Ring of the Stanford Linear Accelerator Centre (SLAC) in California could be interpreted reliably as being due to the first member of a new third family of elementary particles. For this discovery of the tau lepton Martin Perl received the Physics Nobel Prize in 1995.

Perl first mentioned his observations in 1975 at a summer school in Canada. A reliable interpretation of the results he dared only in 1977 at the International Lepton-Photon conference in Hamburg. Perl himself describes this process of clarification of all uncertainties in his memoirs [1] "Is it a Lepton: From Uncertainty and Controversy to Confirmation: 1976-1978."

THE HIGGS – DISCOVERED TWICE?

An example of early communication is the discovery of the Higgs boson at the Large Hadron Collider (LHC) at the European Centre of Nuclear Physics CERN in Geneva. There are two important differences between the discovery of the tau lepton and the Higgs boson: first, Perl's team in 1977 consisted of 36 physicists, while in the discovery of the Higgs boson in 2012 more than 5,000 researchers in two experiments were involved. Second, in 1977 there was not the hype and pressure from the media present in 2012 during the hunt for the Higgs. Already the start-up of the LHC was accompanied by slogans such as "The Hunt for the God Particle" (National Geographic), etc. And third, internal details on the state of the search could not go around the world via new media such as Facebook, Twitter, blogs, etc. within seconds.

High pressure and exaggerated expectations on more than 5,000 physicists and a major international laboratory create an atmosphere that makes an undisturbed completion of the research difficult. The LHC start-up was accompanied by more than 2,500 television broadcasts and 5,800 press articles worldwide, and there were over 100 million hits on the website of CERN. The day before the CERN Colloquium on July 4, 2012, the "Higgsteria" reached an unprecedented level. The auditorium at CERN was literally besieged. The day before, the German "Spiegel" had already promised a "hot trail to the God particle" [2].

On July 4, 2012, the experiments ATLAS and CMS announced the discovery of a "Higgs-like" particle [3]: "CERN experiments observe particle consistent with long-sought Higgs boson," and the Director General of CERN Rolf Heuer said in the historic Colloquium [4]: "As a layman I would say: I think we have it… We have a discovery. We have observed a new particle consistent with a Higgs boson."

In view of the existing uncertainties Heuer suggests to the public the conclusion to be drawn from the measurements. He acts somewhat like Jesus before Pilate who being asked whether he is the King of the Jews answered: "Thou sayest." The subtlety of this trick was of course ignored by the majority of the press which announced triumphantly:

> God Particle Discovered at CERN ("ABC News") [5],
> Physicists Find Elusive Particle Seen as Key to Universe ("The New York Times") [6],
> Sensation! God particle discovered! Have researchers deciphered the origin of the universe? ("Bild") [7],
> Cern scientists discover Higgs boson. What the mysterious, God particle' really means ("FOCUS Online") [8], etc.

It took almost a year of further data taking and analysis until CERN was able to announce on March 14, 2013 in a press release at the international Moriond Conference in La Thuile [9]: "The new particle is looking more and more like a Higgs boson." The press now tried to communicate that the Higgs had been discovered for the second time. The German "Spiegel" states: "Higgs boson: scientists dispel doubts on the God particle" and criticizes: "However, in professional circles it was not without controversy to have gone to the public with the results in July already" [10].
In the same spirit Jan Conrad criticized in "Nature":

> The July 2012 official announcement of the discovery of the Higgs boson with the Large Hadron Collider at CERN … was preceded by press releases of weak but suggestive indications even though there was no competition. That scientists change the wording in their papers from "discovery" to "evidence" or "indication" has little influence on how the results are used [11].

"The New York Times" in its Sunday supplement of December 15, 2013 brought up several aspects of the media campaign about the Higgs particle [12]:

> Hollywood could learn a thing or two about the dark art of self-promotion from this boson. First, its elusiveness "sparked the greatest hunt in science"… Then came all the hoopla over its actual discovery. Or should I say discoveries? Because those clever, well-meaning folks at the CERN laboratory outside Geneva proclaimed their finding of the particle not once but twice. First in 2012 on the 4th of July no less, they told the world did their supergigantic – and awesomely expensive – atom smasher had found tentative evidence of the Higgs. Eight months later, they made a second announcement, this time with more data in hand, to confirm that they had nabbed the beast for real. Just recently, there was yet more fanfare when two of the grandees who had predicted the particle's existence back in 1964 shared a Nobel Prize for their insight.

Although humorously, the columnist rightly points out that you cannot discover something twice. The researchers therefore should not yield too much to the pressure from the media, control their vanity and only go public with safe results. On the other hand, at least from science journalism in high-quality media one should expect sufficient understanding that there may be times of uncertainty in the scientific process during which the state of the research cannot be reduced to a headline.
The *pressure of the media* has consequences for the research process. So it is hard to avoid leaks from the gigantic LHC experiments: the more than 5,000 physicists working in more than 300 teams of the two experiments were urged not to report unpublished results to the sensation-hungry media. This leads first to restrictive safety measures within the experiments, which may hinder the research. Since even the talks of PhD students in local national meetings were followed by the press they are only allowed to show public results and not their own intermediate results. In the dilemma between uncontrollable leaks and the gradual discovery of the Higgs, CERN chose the lesser evil and first announced a Higgs-like particle which later became the Higgs.

NEUTRINOS – FASTER THAN LIGHT

"CERN scientists 'break the speed of light'", the British "Telegraph" announced on September 22, 2011 [13]. Researchers from the OPERA experiment of the Italian Istituto Nazionale di Fisica Nucleare (INFN) in the Gran Sasso tunnel had measured the time of flight of neutrinos generated by a proton beam at CERN in Geneva traveling over 735 km through the Earth mantle to the underground laboratory near Rome. The flight distance determined precisely to several centimeters by GPS and geodesy divided by the time of flight measured to one billionths of a second resulted in a speed greater than the speed of light. CERN said in a press release [14]: "OPERA experiment reports anomaly in flight time of neutrinos from CERN to Gran Sasso."
The Italian Research Minister Maria Stella Gelmini in a press release [15] of her ministry from September 23, 2011 even spoke of an "event that will change the face of modern physics. Exceeding the speed of light is an epochal victory for scientific research around the world."[1] And to the amusement of attentive readers she praised the "construction of the tunnel between CERN and Gran Sasso laboratory, through which the experiment was carried out"[2] [16]. There is of course no 735 km long tunnel from the Gran Sasso near Rome to CERN in Geneva – the all-penetrating neutrinos just travel through the earth.
At the 25th International Conference on Neutrino Physics and Astrophysics in June 2012 in Kyoto four experiments from the Gran Sasso tunnel presented newer measurements which remained under the speed of light. The research director of CERN, Sergio Bertolucci, clarified:

> Although this result is not as exciting as some would have liked, it is what we all expected deep down. The story captured the public imagination, and has people given the opportunity to see the scientific method in action – an unexpected result was put up for scrutiny, thoroughly Investigated and resolved in part thanks to collaboration between normally competing experiments. That's how science moves forward.

Again press and the public were informed very early and were witnesses of an error. Of course, errors and mistakes are part of the research. Moreover, laymen hardly understand

[1] "evento che cambierà il volto della fisica moderna. Il superamento della velocità della luce è una vittoria epocale per la ricerca scientifica di tutto il mondo."

[2] "costruzione del tunnel tra il Cern ed i laboratori del Gran Sasso, attraverso il quale si è svolto l'esperimento."

statistical uncertainties and concepts such as significance, confidence limits, etc. [17] These components of the scientific process are difficult to explain to the public. In times of uncertainty, there is often no simple truth. Therefore both partners of science communication – the researchers as well as the media – should accompany the often lengthy and thorny path to knowledge in a sensitive and insightful way.

SEEK AND YOU WILL FIND – THE BICEP STORY

This saying of the evangelist Matthew is to illustrate the dangers of an aggressive information policy in research. To communicate a "major discovery" in March 2014 four astrophysicists from the experiment BICEP2 invited to an extraordinary press conference [18] of the Harvard-Smithsonian Center for Astrophysics CfA in Cambridge in the USA. The Center for Astrophysics and the Stanford University distributed press releases [19]. The radio telescope located at the South Pole had observed vortex-like patterns in the polarization of the cosmic microwave background radiation.

But the astrophysicists also alleged that this meant the detection of gravitational waves which originate from quantum fluctuations of the extremely strong gravitational field at the beginning of the inflationary expansion immediately after the Big Bang:

> *First Direct Evidence of Cosmic Inflation*. Researchers from the BICEP2 collaboration today announced the first direct evidence for this cosmic inflation. Their data therefore represent the *first images of gravitational waves*, or ripples in space-time. These waves have been described as the "first tremors of the Big Bang". Finally, the data confirm a *deep connection between quantum mechanics and general relativity*.

Andrei Linde and Alan Guth, two prominent fathers of the theory of cosmic inflation, also entered the spotlight of the press.

The news that evidence was found of quantum gravity, gravitational waves and cosmic inflation immediately after the Big Bang immediately dominated the headlines of the worldwide media. Finally, the physicists claimed to have progressed at least twenty orders of magnitude on the time scale closer to the Big Bang – a gigantic and historically unique step [20]! In view of that they should have respected an old rule of research: *Extraordinary claims require extraordinary evidence* [21].

The BICEP team published an article in the Internet declaring the beginning of a new era in cosmology [22]: "The long search for tensor B-modes is apparently over, and a new era of B-mode cosmology has begun." The Internet portal of the journal "Nature" quoted Alan Guth of the MIT in Cambridge (Massachusetts), one of the fathers of the idea of the inflationary universe: "This is a totally new, independent piece of cosmological evidence that the inflationary picture fits together" [23]. Guth added that these measurements are definitely worth a Nobel Prize. The "Frankfurter Allgemeine" announced on the Internet: "Echo of the Big Bang – gravitational waves confirm inflationary universe" [24].

But soon doubts and criticisms came up [25]. So the American scientific journal "Science" wrote in May 2014 under the head line "Blockbuster could collapse claim in a cloud of dust" [26]:

> Perhaps it was too good to be true. Two months ago, a team of cosmologists reported it had spotted the first direct evidence that the newborn universe underwent a mind-boggling exponential growth spurt known as inflation. But last week a new analysis suggested the signal, a subtle pattern in the afterglow of the Big Bang, or cosmic microwave background (CMB), could be an artifact produced by dust within our own galaxy.

In June 2014 BICEP had to post a new version of their paper [27] which was based on openly accessible information from ESA's Planck satellite. The authors admitted that the signal could also originate from the emission of galactic dust and is therefore not necessarily of cosmological origin.

One of the critics was the American astrophysicist David Spergel, who had analyzed the background radiation in the WMAP project, the predecessor of the Planck satellite. In an interview [28] published in the "Scientific American" on July 24, 2014 he answered to the question: "Did the press overreact?": "I do not blame the press for going with the smoking-gun story, but I do fault the BICEP2 project scientists for overreaching, for making claims that are not fully supported by their own data."

In view of the now published analysis of the data [29] of the Planck satellite "Science" writes in September 2014 under the subtitle: "The biggest result in cosmology in a decade fades into dust" [30]: "A beleaguered claim that appeared to reveal the workings of the big bang may instead say more about how science is done in an age of incessant news coverage… BICEP researchers felt pressure from the media to stake a definite claim" and quotes a cosmologist: "They're trying to translate this into something that the public can understand, and they want a yes or no." As a member of the Planck collaboration said to "Science" his team intentionally abstained from a press release [30]: "It's very tricky stuff, so we were anxious that it not go into the press as 'Planck says that BICEP is wrong' because it doesn't."

The Planck team reacted so careful in order not to damage the scientific process and their competing colleagues by going public too quickly. On the question: "Is all this back and forth about BICEP2 damaging the field, or is this simply the way science is done" the director of the Perimeter Institute for Theoretical Physics in Canada, Neil Turok told the "Scientific American" [31]:

> Both. I think a lot of people want to take pause at this point and acknowledge there was too much hype about the results, too many claims made, and instead we need to be a little more cautious and scientific and really allow the evidence to be settled.

In early 2015 a joint analysis of BICEP and Planck data showed that the effect can be almost entirely explained by

interstellar dust [32]. The "Los Angeles Times" summed up: "Cosmic Inflation: Dust finally settles on BICEP2 results" [33] while Jan Conrad rightly complains in "Nature" that "the original BICEP2 paper has ten times more citations than the final word" [11]. A drastic verdict on the inglorious end of this "discovery" proclaimed with so much arrogance was pronounced by the German "Frankfurter Allgemeine": "You may turn and turn the dirt, it remains dirt"[3] [34].

THE PENTAQUARK STORY

The search for pentaquarks may serve as a last example. During the last decades particle physicists were desperately seeking for these elementary particles consisting of five and not just three quarks like ordinary nucleons. They are predicted by the quark model. On March 11, 2004, the H1 experiment at the Deutsches Elektronen-Synchrotron (DESY) in Hamburg announced the observation of such a five-quark state including a charm quark [35]. The competing ZEUS experiment at DESY could not confirm the discovery, but published on March 30, 2004 a pentaquark state with strangeness, which in turn was not confirmed by the H1 experiment [36]. The observation was cautiously made public on the DESY web pages [37] and in the press. At the end of the whole story came to nothing.

A decade later, in 2014, the 1700-page "Review of Particle Physics" summarized the history of pentaquarks as follows [38]:

> The only advance in particle physics thought worthy of mention in the American Institute of Physics "Physics News in 2003" was a false alarm. The whole story – the discoveries themselves, the tidal wave of papers by theorists and phenomenologists that followed, and the eventual "undiscovery" – is a curious episode in the history of science.

Only in 2015 and due to its much higher sensitivity the LHCb experiment at CERN finally observed serious pentaquark signals [39].

SCIENCE AND MEDIA – A PACT WITH THE DEVIL?

Within three years, from 2011 to 2014, the public thus experienced the "twofold" discovery of the Higgs particle, the fiasco of the superluminal neutrino velocity and the premature announcement of the observation of cosmic inflation. These examples may serve as a warning to both the researchers and the media.

The BICEP case had immediate consequences. When asked in the "Scientific American": "How do you think this controversy will affect the public's perception of how science works," David Spergel replied [40]:

> The optimistic scenario is indeed the public will say, hey, this is great, it helps science when people check each other's data… The negative side is…: If the scientists get gravity waves wrong, why should we believe them on global warming?

Faced with such doubt the ethos of research is at stake. Jan Conrad recently initiated a discussion of this problem in the journal "Nature" [11]. He is worried "that false discoveries are undermining public trust in science" and asks: "…why should anyone believe that any scientific result will hold?" He proposes several measures of quality control in scientific publishing. Jon Butterworth partially contradicts him in the "Guardian" [41] and argues that false alarms may even "help build understanding."

The Higgs story is one of the most exciting and happiest episodes in the history of science. It demonstrates in an ideal way the scientific method proceeding from the theoretical prediction of the Higgs particle through the decades of search to its successful detection at CERN.

This process was accompanied by an extraordinary public interest. The start-up of the LHC and the announcement of the discovery of the Higgs particle were the largest media events in the history of science. In a world which is not free of ignorance and fears of progress and of nuclear research such an overwhelming interest is a lucky chance for science.

Without this tremendous public interest funding agencies would barely support expensive research. This extraordinary interest, however, also bears risks of the interaction between science and the media:

- Inappropriate or false concepts like the God particle or microscopic black holes can create false images or even fears that may become detrimental to science.
- If science asks for public attention before it has reliable results, it risks its reputation and its most precious good: credibility.
- Pressure from the media on the scientists may hinder the research process. The media should avoid hunting for sensations and accompany the thorny and twisty ways to truth critically and competently.

We have shown how delicate the interplay between research and media is and how much insight and responsibility both sides should apply.

Scientists fire up public attention and the media hunt for news. This can lead to a pact with the devil: the scientist finds himself in the situation of the sorcerer's apprentice: he can't get rid of the ghosts he called. He becomes both actor and victim. Instead of such a devil's pact research and media should closely cooperate to inform and educate the public in the spirit of truth and enlightenment.

[3] Wie man den Dreck auch dreht und wendet, es bleibt Dreck.

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