Phys. Perspect.

https://doi.org/10.1007/s00016-024-00306-9

Physics in Perspective

A New Literary Style of Science: The Rise of Acronyms in Physics and Astronomy

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Research articles in all branches of modern science are crowded with the abbreviated technical terms known as acronyms, a phenomenon that was essentially unknown before World War II. Apart from an introduction to the notion of acronyms and its short history, the paper discusses from a historical perspective the connections between acronyms and eponyms in science. Moreover, it charts how acronyms and abbreviations became so common in physics and astronomy that the excessive use of them came to be considered a symptom of a contagious disease. While many science acronyms are exotic and little used, and some downright bizarre, others have become household words that in some cases are not even recognized to be acronymic constructions. The paper briefly examines the naming histories of some of these successful acronyms in physics and astronomy, among them radar, sonar, maser, laser, and pulsar.

Key words: Acronyms; Abbreviations; Eponyms; Names; DNA; Sonar; Maser; Laser; Quasar.

Introduction

From about 1960 the vocabulary of physics and its allied sciences changed drastically in two respects, the one concerned with new words and the other with abbreviations and acronyms. With respect to the nomenclature there was in the period an almost complete break with the established tradition of forming new words preferably from Greek roots. Now freely created and often whimsical terms increasingly entered the scientific vocabulary. As observed by one physicist, "In the latter half of this century … the language of physics is undergoing a shift from its classical and honorific traditions to a metaphoric mode."[1] Examples of fantasy words with no connection whatsoever to the classical languages abound in the terminology of particle physics and elsewhere, witness terms such as "quark" and "gluon" from the 1960s, not to mention the later "charmonium," "anyon," and "boojum."[2] At about the same time scientists began making massive use of acronyms, a phenomenon largely unknown in the pre-World-War II era.

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Birkhäuser

Published online: 18 March 2024

In a paper of 1929, Otto Jespersen, a Danish linguist of international reputation, dealt with the formation of new words in various branches of science. He also briefly mentioned.

> … a highly linguistic trick that has lately come into fashion in many countries, namely that of coining terms from the initials of a composite expression, which are read either separately with the traditional names, as in Y.M.C.A. … or pronounced together, as *Dora* (Defense of Realm Act). This fashion was especially in vogue during the late war.[3]

He had acronyms in mind but did not use the term, which had not yet been invented and, according to the *Oxford English Dictionary* (henceforth *OED*) only appeared in English in the early 1940s. The term first appeared in print in February 1943, briefly introduced as follows: "Your correspondent who asks about words made up of the initial letters or syllables of other words may be interested in knowing that I have seen such words called by the name *acronym*, which is useful and clear to anyone who knows a little Greek."[4] Nor did Jespersen give examples of abbreviations in the form of acronyms used by scientists, probably for the reason that this "linguistic trick" was still practically unknown in scientific publications. Acronyms only entered the language of science significantly after World War II and have since then increased explosively in number and variation.

Following a general introduction to the linguistic concept of acronymy and its short history, this paper examines the use and misuse—so-called acronymania—in post-1950 science with an emphasis on physics and astronomy. One of the sections pays attention to the way in which scientific eponyms appear in the form of acronyms. The article ends with more detailed descriptions of some prominent science acronyms including radar, laser, quasar, and pulsar.

On Acronyms and Abbreviations

First, what is an acronym? Based on the Greek syllables *acr* (height, summit) and *onym* (name), an acronym is a word usually formed by the initial letters of a longer word or phrase as in IUPAP (*I*nternational *U*nion of *P*ure and *A*pplied *P*hysics) and SUSY (*su*per*sy*mmetry). Many acronyms can be pronounced as words, but there are also many spoken of in terms of the individual letters of which they consist. Examples of the latter category are TV (*t*ele*v*ision), DNA (*d*eoxyribo*n*ucleic *a*cid), GPS (*G*lobal *P*ositioning *S*ystem), and the multiple eponym EPR (*E*instein–*P*odolsky–*R*osen) about which more below. Abbreviations of this kind are sometimes called initialisms (or alphabetisms) and not acronyms, but at other times initialisms are included in the acronymic umbrella term.

There seems to be no agreement among linguists with regard to the precise definition of acronyms and how it differs from related categories such as abbreviations, initialisms, clippings, and shortenings.[5] Some scholars want to restrict the term 'acronym' to initial-letter abbreviations with three or more letters, implying

that terms such as TV and FM (*f*requency *m*odulation) are not proper acronyms. Others include the requirement that an acronym can be pronounced as a word, which would turn DNA into a non-acronym. As stated in a dictionary from 1957, acronyms "serve the same purpose as abbreviations, but are primarily designed for speech and appeal more to the ear than to the eye."[6] However, in current usage there is no essential difference between acronyms and initialisms, nor are words consisting of two letters only excluded.

Some acronyms which cannot be pronounced as a whole contain a part which can and they are spoken of accordingly, typically as both letters and words. Thus PFAS (*p*er- and poly*f*luoro*a*lkyl *s*ubstances) is pronounced P-fas and IUPAP as I-U-pap. Many of the widely used acronyms have replaced their original sources and effectively become independent words, or as they are sometimes called, pseudo-neologisms because they contain existing words. They have entered common language and are used by speakers or writers without knowing of or caring about their origin. Examples of such words from the world of science are DNA, DDT, radar, and laser. Few will know that these acronymic words stand for, respectively, *d*eoxyribo*n*ucleic *a*cid, *d*ichloro*d*iphenyl*t*richloroethane, *ra*dio *d*etection *a*nd *r*anging, and *l*ight *a*mplification by *s*timulated *e*mission of *r*adiation.

The signs of which a scientific acronym is composed are in almost all cases ordinary Latin letters, but there are a few exceptions where other signs, such as Arabic numerals or Greek letters, enter the acronym. A noteworthy example of the latter is the standard designation for the so-called cosmological concordance model, namely ΛCDM with CDM standing for Cold Dark Matter. The first term in the acronym is the Greek capital letter lambda, which refers to Einstein's cosmological constant and its manifestation in the form of dark energy. The widely used acronym is pronounced lambda-CDM and sometimes appears in writing in this form instead of using the Greek Λ. While the CDM acronym was introduced in about 1990, it took another five years until ΛCDM or lambda-CDM was coined. The title of a paper in *Astrophysical Journal* published in 1997 included not only ΛCDM but also CHDM (*c*old and *h*ot *d*ark *m*atter).[7]

Acronyms go far back in time, witness the emblematic Roman abbreviation SPQR (*s*enatus *p*opulusque *r*omanus) and the later RIP (*r*equiescat *i*n *p*ace, better known as *r*est *i*n *p*eace). Although these kind of abbreviations continued to be used in the literature, acronyms became more frequent only during World War I, such as noticed by Jespersen. And yet, still in the 1930s they were comparatively few and mostly limited to the language spoken within political, military, and corporate areas of society.[8] A more systematic increase occurred during and after World War II, primarily in the United States,[9] but for a decade or so with no significant forming of science acronyms. According to S. V. Baum, an American linguist writing in the journal *American Speech* in 1955, "The acronym seems to have become almost the private property of political language."[10] He referred to two of the important military inventions of World War II, the RADAR and the

LORAN (*Lo*ng *Ra*nge *N*avigation), the latter a radio navigation device used by the American military for ships and aircraft.

The complex radar projects on both sides of the Atlantic included a large number of abbreviations and non-acronymic code names such as Pelican, Pterodactyl, and Beavertail. However, it also made use of several acronyms based on initials, among which were ASV (*a*ircraft to *s*urface *v*essel), ART (*a*utomatic *r*ange *t*racking), PPI (*p*lan-*p*osition *i*ndicator), and MEW-MTI (*m*icrowave *e*arly *w*arning-*m*oving *t*arget *i*ndicator).[11] The one other group that Baum mentioned in his article on acronyms, apart from politicians and the military, were scientists and engineers developing the early generations of programmable electronic computers from the primitive ENIAC (*E*lectronic *N*umerical *I*ntegration *a*nd *C*omputer) to the much more advanced MANIAC (*M*athematical *A*nalyzer *N*umerical *I*ntegrator *a*nd *C*omputer).

Baum seems to have been unaware that by 1955 a number of important acronyms had already entered the medical and scientific literature. The most successful of these early science acronyms, and possibly the most successful ever, namely DNA, first appeared in a paper of 1942 together with the related acronym RNA (*r*ibo*n*ucleic *a*cid).[12] Since about 1980, DNA has appeared in the book literature with a frequency of about forty-five per million words, which makes it as popular as common words like efficient, egg, and shop (Figure 1).[13] According to an analysis by Adrian Barnett and Zoe Doubleday based on more than twenty-four million article titles and eighteen million article abstracts published between 1950 and 2019, the DNA acronym appeared about 2.44 million times.[14]

Others of the very popular acronyms from the area of biomedicine include HIV (*h*uman *i*mmunodeficiency *v*irus; 1.17 million) and the four-letter mRNA (*m*essenger *r*ibo*n*ucleic *a*cid; 1.11 million). As shown by Barnett and Doubleday, the proportion of acronyms in titles in scientific papers has increased from 0.7 per 100 words in 1950 to 2.4 per 100 words in 2019. In cardiological trials alone, acronyms increased from 250 in 1992 to nearly 4,200 ten years later. Moreover, only few of the thousands of acronyms were used regularly and three-letters words of this kind were more popular than words with two or four letters. "New acronyms are too common, and common acronyms are too rare," Barnett and Doubleday comment. It should be pointed out, though, that the study in question defines an acronym in the narrow sense of "a word in which half or more of the characters are upper case letters," which excludes, for example, commonly used terms such as laser, radar, and quasar.

Acronymania

Although it is universally agreed that acronyms are useful and indeed indispensable in modern science, with the rapid rise of these word formations in the 1960s some scholars began expressing doubts as to the sheer number of acronyms, their structure, their ambiguity, and the indiscriminate way in which they were used. As

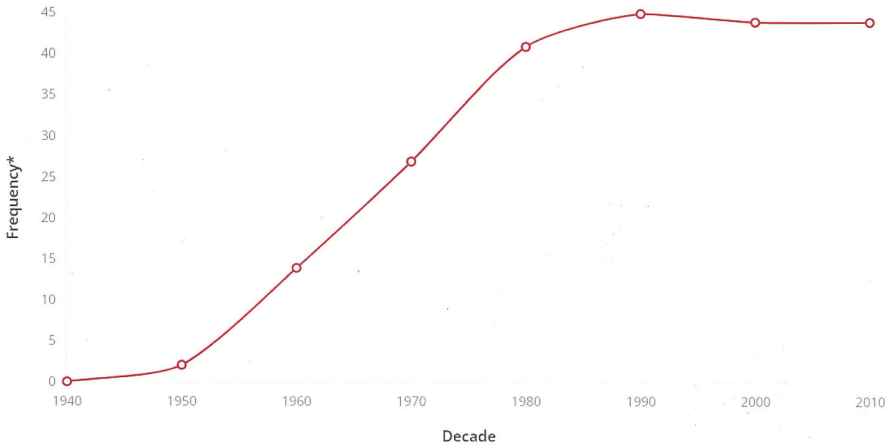

Fig. 1. The rise of DNA, one of the most successful scientific acronyms. The measure of the frequency (ordinate axis) is the term's occurrence per million words in modern written English. *Source*: Oxford English Dictionary

early as 1962 the editors of the *New England Journal of Medicine* gave voice to their unease with abbreviations and acronyms, and since then the acronym issue has been addressed time and again in the medical literature.[15] Inevitably, the word *acronymania* was coined for the obsession of creating new and often weird acronyms. The neologism was coined by Eric Jamieson in a 1968 editorial in *New Scientist* in which he described the overuse of acronyms as a contagious disease:

> Meaningless, ambiguous, unpronounceable and less than euphonious is the picture one gets of acronyms. … To be fair, there are exceptions. In every craze, whether it be Hula Hoops or Miniskirts the best is often attractive, although the worst is frankly appalling, and acronymania is no exception to this general rule.[16]

A few years later, Eugene Garfield, the American linguist and co-founder of scientometrics as a new field of information science, expressed his irritation that new abbreviations sometimes appeared without explanation in the title and abstract of scientific papers.[17] As regards the number of acronyms used in modern science and technology, it is unbelievably large, such as illustrated by the *International Encyclopedia of Abbreviations and Acronyms in Science and Technology*, a work that in its 1999 edition comprised 10 volumes with a totality of approximately 850,000 entries.[18] To find one's way in the jungle of acronyms has become an art in itself. As pointed out by the editor of the journal *Accounts of Chemical*

Research, not all young scientists are sufficiently "acronymble" to cope with the problem.[19]

Within the field of ion beam analysis (IBA), an active branch of applied solid-state physics, the problem was discussed at a workshop held in Tempe, Arizona, in 1995. Summarizing the discussions and the recommendations that followed from the workshop, the French physicist Georges Amsel playfully coined a new acronym, namely CUTBA (*c*leaning *u*p the *t*ower of *b*abel of *a*cronyms). In agreement with other critics of the tendency toward acronymania, he wrote:

> One observes in recent literature an increasing trend to introduce new ad hoc acronyms for specific applications or techniques, although names already exist that may be adapted to correspond rather accurately to the concept. In the present situation even people well informed of this field have more and more difficulties to understand what is meant by, for example, ESS, PES, HIRBS, CERDA, CCM or CSTIM. This is especially true when the acronyms are used in titles or abstracts, without definition.[20]

The attempts to restrict the use of acronyms in physics and elsewhere seem not to have been very successful. At least, complaints about the problem continue to be voiced in scientific journals. A recent editorial in *Nature Physics* followed up on Amstel's CUTBA with another ironical anti-acronymania acronym, this time APRIL (*a*bbreviations *p*revent *r*eadability and diminish *i*nf*l*uence). According to the journal:

> At *Nature Physics*, we want to make our papers accessible to a large NOPE [Number Of PEople], and we therefore recommend using As Few Acronyms And Abbreviations As Possible (AFAAAAP) and, if they are necessary at all, stick to a Short and Evocative Acronym List (SEAL) with items that are Widely used, Obvious, Known and Easy to remember (WOKE).[21]

Today it is widely recognized that obscure acronyms are heavily overused in scientific papers and that they tend to hinder understanding by non-specialists in particular. Acronyms in medicine were originally built from the first letters of words, as in HIV and CKD (*c*hronic *k*idney *d*isease), but later any letter or letters appearing in a word would do. They may even be composed of other acronyms as in TAPS = *T*PA *A*PSAC *P*atency Study, where TPA = *T*issue *P*lasminogen *A*ctivator and APSAC = *A*nisoylated *P*lasminogen *S*treptokinase *A*ctivator *C*omplex. Such nested acronyms, as they have been called, are also known from other fields of science. In physics, CERN's ATLAS detector experiment stands for *A T*oroidal *L*HC (*L*arge *H*adron *C*ollider) *A*pparatu*s* and in astronomy, JADES is an acronym for *J*WST (*J*ames *W*ebb *S*pace *T*elescope) *A*dvanced *D*eep *E*xtra-galactic *S*urvey.

According to Herbert Fred and Tsung Cheng, two American professors of medicine writing in 2003, the development of acronymania had gone too far: "The goal seems to be finding an acronym that is cuter and wittier than the previous one.

… We have reached the point where investigators are selecting a colorful acronym, and then dreaming up a suitable study to match it."[22] Some of the astronomical acronyms mentioned below suggest that the comment is not far off the mark.

In his 1968 article in *New Scientist*, Jamieson referred to AIDS as an acronym for *a*utomatic *i*nformation *d*ata *s*ervice, but when the HIV-AIDS disease was recognized thirteen years later, the same acronym came to stand for *a*cquired *i*mmune *d*eficiency *s*yndrome. Indeed, as Fred and Cheng pointed out, not only were there too many and too undisciplined acronyms, a particular acronym often referred to very different meanings even in the same scientific speciality. Thus, by 2003 HEART represented 16 different medical studies or methods, one of them *H*ealth *E*ducation *A*wareness and *R*esource *T*eam and another *he*parin *a*nticoagulation *r*egime *t*reatment. DNA is a key acronym in genetics, but the same combination of letters appears with about thirty other meanings (random examples are *d*id *n*ot *a*ttend, *d*efence *n*uclear *a*gency, and *d*igital *n*etwork *a*rchitecture). On the top of that, many acronyms are one-timers in the sense that they are found only in the papers in which they were introduced and are not mentioned either in other papers or in dictionaries of acronyms and abbreviations. An early study of a random sample of forty acronyms in the physics literature 1973–74 showed that about half of the sample belonged to this category.[23]

Astronyms

Apart from the health sciences, acronyms proliferated early on in the space sciences and their numerous organizations, projects, and missions. Established in 1958 on the basis of the already existing NACA (*N*ational *A*dvisory *C*ommittee for *A*eronautics), NASA is usually understood as an acronym for *N*ational *A*eronautics and *S*pace *A*gency. But as *Science News* playfully pointed out in a column of 1975, there were other meanings as well:

> As the most high-technology agency around, the chief offender (or victim), of course, is NASA. (Never mind what it stands for, though rumor-mongers once came perilously close to the truth in suggesting the National Acronym-Slinging Agency.) The Skylab project alone, for example, produced a 136-page, small-type volume of 'astronyms'.[24]

Later developments in astronomy, astrophysics, and aeronautics have given birth to a frighteningly large number of acronyms and abbreviations.[25] Some of the more recent belong to a category which Harvard astrophysicist Glen Petitpas has called DOOFAAS or *d*umb *o*r *o*verly *f*orced *a*stronomical *a*cronyms.[26] Among the 427 dodgy words in his list are not only BATMAN (*ba*sic *t*ransit *m*odel c*a*lculatio*n*), BOOMERanG (*B*alloon *O*bservations *O*f *M*illimetric *E*xtragalactic *R*adiation *an*d *G*eophysics), and AVOCADO (*A V*irtual *O*bservatory *C*ensus to *A*ddress *D*warfs *O*rigins), but also decidedly weird acronyms such as

ABRACADABRA (*A Broadband/Resonant Approach to Cosmic Axion Detection with an Amplifying B-field Ring Apparatus*) and GADZOOKS! (*Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande, Super!*). One more example is 11HUGS (*11* Mpc H_α and *U*ltraviolet *G*alaxy *S*urvey). As noted by Benjamin Cook, another Harvard astrophysicist, "As a group, astronomers are likely surpassed only by U.S. lawmakers in their love of convoluted acronyms."[27]

At the 225th meeting of the American Astronomical Society held in Seattle in 2015, the trend toward tortured astronomy acronyms was on display. One of the attendees commented:

> While the standard rule of creating an acronym requires taking the first letter from each word, many astronomical groups bend this rule a bit, as in the case of the AGHAST survey, which stands for A Grism H-Alpha SpecTroscopic survey, or in the case of the computer program TIRIFIC (Tilted Ring FiTng Code). Sometimes acronyms have duplicate words, as in the case of ALFALFA: the Arecibo Legacy Fast ALFA survey (ALFA stands for Arecibo L-band Feed Array). These clever and often humorous acronyms tend to belong to smaller experiments, surveys, collaborations and projects. Large projects tend to be more reserved when it comes to creative acronyms.[28]

There is a longstanding tradition in physics and astronomy for combining serious studies of nature with humour, puns, and jocular expressions, and as pointed out by Douglas Scott, a Canadian astrophysicist, the weird acronyms fit nicely into this tradition going back to Maxwell if not earlier.[29] High-energy physicists have followed up on their acronymanic colleagues in astronomy, although not with quite as many and quite as fanciful acronyms.[30] The term high-energy physics dating from the late 1950s is generally abbreviated HEP, a standard acronym with dozens of other meanings, among them hepatitis.

CERN was permanently established in 1954 with its name being an acronym for *C*entre *E*uropéen pour la *R*echerche de *N*ucléaire. Although nuclear research in the traditional sense soon became irrelevant, the French-inspired acronym has been retained. Among the best known and most successful of CERN's many accelerator facilities are the LHC (*L*arge *H*adron *C*ollider) and the now dismantled LEP (*L*arge *E*lectron–*P*ositron Collider), both names being conservative standard acronyms. This is also the case with the American SLAC facility (*S*tanford *L*inear *A*ccelerator *C*enter) with its former SPEAR collider which was originally an acronym for *S*tanford *P*ositron *E*lectron *A*symmetric *R*ings. It is hard to imagine prestigious and very expensive institutions like CERN and SLAC—not to mention NASA—with names of the ABRACADABRA kind. Although CERN houses or has housed experiments with slightly more colourful acronyms, such as ALICE (*A L*arge *I*on *C*ollider *E*xperiment) and DELPHI (*De*tector with *L*epton, *P*hoton and *H*adron *I*dentification), these are a far cry from the exotic and frivolous acronyms of the astronomical research projects mentioned above.

On the other hand, colourful acronyms do exist in astroparticle physics and among them WIMP and MACHO merit attention. Primarily with the purpose of explaining the mysterious dark matter, physicists contemplated that it might consist of hypothetical non-baryonic particles with no place in the standard model. These were called WIMPs (*w*eakly *i*nteracting *m*assive *p*articles), an acronym coined by Gary Steigman and Michael Turner in a 1985 paper.[31] The English noun wimp typically refers to a feeble person, a coward, or weakling, a connotation that Steigman and Turner may have had in mind when they suggested the acronym. As an alternative to WIMPs, other physicists considered what came to be known as MACHOs, an acronym dating from 1991 and due to the American astrophysicist Kim Griest. Concerning the nature of dark matter, he wrote: "It could also consist of massive astrophysical objects such as brown stars, Jupiters, or black hole remnants of an early generation of stars. (As a major alternative to WIMPs, this latter class should surely be collectively called massive astrophysical compact halo objects [MACHOs])."[32]

In the later literature the meaning of the MACHO acronym is typically stated as the simpler *ma*ssive *c*ompact *h*alo *o*bjects. WIMP and MACHO were quickly accepted, the first appearing in the title of a research paper in 1985 and the second in 1991. More recently WIMPs have been followed by other hypothetical dark matter candidates and corresponding acronyms, among them FIMPs (*f*eebly *i*nteracting *m*assive *p*articles) and SIMPs (*s*trongly *i*nteracting *m*assive *p*articles).

Multiple Eponyms as Acronyms

Eponyms are as abundant in the scientific literature as are acronyms, and the tradition of naming things in science after persons is much older than the corresponding use of acronyms.[33] The things named after a person or several persons cover a broad spectrum including theories, constants, laws, equations, objects, instruments, phenomena, units, and more. Although usually named after scientists, physicians, and inventors, in several cases eponyms refer to mythical figures (e.g. Aphrodite) or to people with no connection whatsoever to the world of science (e.g. Mike Jagger). Some eponymous diseases are named after patients and not after the physician who first identified the disease.

The total number of eponyms in science is unknown but dauntingly large. In medicine alone the number is estimated to be of the order 20,000 which suggests that at least 50,000 eponyms have been in circulation through history. Many of those used in the past have disappeared only to be replaced by new eponyms. Although the number of new eponyms has not followed the growth of science in the post-World War II era, there is no indication that the old tradition of celebrating scientific progress with eponyms is fading away. It is only in relative terms that there are fewer of them in modern science.[34] More recently objections to the eponym naming tradition have intensified, either with respect to particular

eponyms or, more broadly, to the tradition itself which is claimed to be problematic for scientific, political, and ideological reasons.[35]

Personal proper names can in a few cases be initialized and thus turned into acronyms (e.g. JFK meaning *J*ohn *F*itzgerald *K*ennedy), but such practice is, as far as I am aware, unknown for scientists. When initials for a single scientist appear in an eponym, it is always as part of a longer acronym, as in HST (*H*ubble *S*pace *T*elescope), CGRO (*C*ompton *G*amma *R*ay *O*bservatory), JWST (*J*ames *W*ebb *S*pace *T*elescope), and WMAP (*W*ilkinson *M*icrowave *A*nisotropy *P*robe) with the latter named in honour of the American cosmologist David Todd Wilkinson. In agreement with the generally accepted rule not to name scientific instruments after living scientists, the microwave probe was originally called MAP and only renamed WMAP, pronounced W-map, after Wilkinson's death in 2002. There is also a substantial number of multiple eponyms that refer to two or more scientists and these too occasionally appear in the form of acronyms. Expectedly, double eponyms are more frequent than triple eponyms and there are very few with four or more names. Examples of the first group include Bose–Einstein statistics (quantum theory), Maxwell–Boltzmann distribution (statistical mechanics), Biot-Savart law (electrodynamics), and Haber–Bosch process (industrial chemistry).

In a few cases double eponyms have been abbreviated to acronyms, such as is the case with the Geiger-Müller tube invented by German physicists Hans Geiger and Walther Müller. The tube is often referred to as a G-M or GM tube, whereas the counter of which the tube is a part is either called a Geiger counter (a noun that appears in *OED*), a Geiger-Müller counter, or more rarely a GM counter. Another example of some interest is what modern astrophysicists sometimes call the KH mechanism, the KH time scale, and the KH instability with the first letter referring to Lord Kelvin and the second to Hermann Helmholtz. The abbreviation KH (*K*elvin–*H*elmholtz) is unfortunate from a historical point of view since the theory in question concerned with the energy produced by a stellar body's gravitational contraction was first suggested by Helmholtz in 1854 and only later developed by Kelvin, who at the time was William Thomson and not yet had become Lord Kelvin.[36] Web of Science lists 6,300 papers with "Kelvin–Helmholtz," a term accepted by *OED*, and only nine with "Helmholtz-Kelvin" (and none with Thomson instead of Kelvin).

Among the 3-letter acronymic eponyms in the field of medicine there is the AKL syndrome, where AKL stands for the not easily pronounceable Abderhalden-Kaufmann-Lignac. Historians of quantum physics know about the BKS theory, an important but short-lived radiation theory proposed in 1923 by Niels Bohr, Hendrik Kramers, and John Slater as an alternative to Albert Einstein's photon theory. However, in this case the acronym is a later construct as it was not used at the time. Possibly introduced by the Dutch physicist Hendrik Casimir in 1982, the BKS abbreviation mostly appears in writings by historians of science.[37] Besides, modern quantum physicists and philosophers will associate BKS with a certain theorem concerning the interpretation of quantum mechanics due to John

Bell, Simon Kochen, and Ernst Specker (often referred to as just the Kochen-Specker or KS theorem).

I shall pay a little more attention to the acronymic labels EPR and BCS, the first referring to Einstein–Podolsky–Rosen, and the second to Bardeen-Cooper-Schrieffer. The now so famous thought experiment or "paradox" published in 1935 in *Physical Review* by Einstein, Boris Podolsky, and Nathan Rosen is usually cited as the acronym EPR with only one tenth of the more than 23,000 scientific references using the full unabbreviated form (Web of Science). Originally the EPR paper was little noticed and yet the EPR acronym was introduced as early as 1936 by the American physicist Wendell Furry, who used it throughout his paper.[38] The same year it was employed, without explicitly noting that EPR was an acronym for Einstein–Podolsky–Rosen, by another American, the physicist and philosopher Victor Lenzen.[39] For the next twenty years or so, EPR was rarely used. Like other acronyms, the eponymous EPR has no monopoly on the string of letters. Many scientists will associate the acronym with electron paramagnetic resonance, a much-used spectroscopic method dating from the 1940s.

In 1972 John Bardeen, Leon Cooper, and John Schrieffer shared the physics Nobel Prize for a fundamental theory of 1957 that offered a microscopic explanation of superconductivity in terms of quantum mechanics. Rather than referring to the more cumbersome name Bardeen-Cooper-Schrieffer theory, physicists quickly learned to use the acronym BCS, which first appeared in the title of an article in 1958.[40] While Web of Science gives 690 results for "Bardeen-Cooper-Schrieffer + superconductivity," the number for "BCS + superconductivity" is much larger, namely 4,010. On a few occasions the abbreviation is given as BSC and not BCS. Of course, there are many other non-eponymous acronyms in the field of superconductor physics. High-temperature superconductivity is usually abbreviated HTS. A class of ceramic superconductors consisting of bismuth, strontium, calcium, copper, and oxygen is known as BSCCO.

There are not many four-letter acronyms that refer to scientists, but there are some, of which I single out FLRW and B2FH that belong to the fields of cosmology and astrophysics, respectively. With the acceptance of the expanding universe most cosmologists agreed that space–time can be described by a so-called metric corresponding to a wide class of relativistic models. The full name is the Friedman-Lemaître-Robertson-Walker metric or model, a multi-eponym referring in both alphabetical and chronological order to the four scientists responsible for it, namely Alexander Friedman (often spelled Friedmann), Georges Lemaître, Howard P. Robertson, and Arthur G. Walker. In many cases the names are not spelled out but instead appear acronymically as FLRW or often as just RW (Robertson-Walker) with Friedman and Lemaître left out. The abbreviations RW and FLRW were only used after about 1970. Whereas the two-word eponym Robertson-Walker is more popular than the RW acronym, FLRW is more popular than the little-used Friedmann-Lemaître-Robertson-Walker.

In a landmark paper of 1957 four astrophysicists, one American and three Britons, presented in detail a comprehensive theory of stellar nuclear synthesis. This most important theory is generally known as the B^2FH (or B2FH) theory, an unusual acronym referring to the four authors in alphabetical order: Geoffrey Burbidge, Margaret Burbidge, William Fowler, and Fred Hoyle. The term Burbidge-Burbidge-Fowler-Hoyle theory is almost never used. As the Bardeen-Cooper-Schrieffer theory from the same year was quickly acronymized to BCS, so it happened with the theory explaining the formation of elements in the stars. Instead of becoming BBFH, the two Burbidges were squared to B^2, an innovative notation introduced in a paper of 1959 in which the author stated in a footnote, "Hereinafter referred to as B^2FH."[41] The same year Hoyle spoke of the theory as BBFH, an acronym also used by a few other authors in the 1960s.[42]

Finally, I am only aware of a single eponymous science acronym or abbreviation referring to more than four scientists. In the literature on strong-interaction particle physics in the 1970s there are dozens of references to the "ABFST model" and "ABFST equation," where the letters stand for five Italian physicists, D. Amati, L. Bertocchi, S. Fubini, A. Stanghellini, and M. Tonin. The paper in which the American physicist Don Tow introduced the five-letter acronym was submitted to *Physical Review* with the title "Some Predictions of the ABFST Multiperipheral Model," but when it appeared in print the title read "Some Predictions of the Amati-Bertocchi-Fubini-Stanghellini-Tonin Multiperipheral Model."[43] Apparently the editors of the journal had objected to a title with an acronym not previously used and therefore unknown to other physicists.

Some Examples of Acronyms in Physics and Astronomy

In some cases, we know how acronyms in science were formed, by whom, and for what reasons. The following case studies are brief descriptions of the historical origin of some important names and acronyms principally belonging to technology, physics, and astronomy.

Radar and Sonar

Radar was originally an American code word for *ra*dio *d*etection *a*nd *r*anging suggested by Samuel M. Tucker from the US Navy and adopted by the Navy in November 1940 as the designation for what had been previously called "radio echo equipment." The name was accepted by the US Army in 1942, and in July the following year the British replaced their own term RDF (*r*adio *d*irection *f*inding) by radar.[44] It appeared in public even earlier, namely in the *New York Times* of 2 October 1941 and is today a household name with a frequency of about seven words per million written words in modern English.[45]

The sonar method of navigation and detection of submarines goes back to World War I, when it was developed by the French physicist Paul Langevin and

others. However, the name was only coined after radar had appeared and it was modelled on this new word. The inventor of "sonar," an acronym for *so*und *na*vigation and *r*anging, was Frederick Vincent Hunt, a physicist and specialist in acoustics working for the US Navy at Harvard's Underwater Sound Laboratory. In about 1942, Hunt discussed with a colleague at the Navy Bureau of Ships, Chris Engelman, how they could "make the job as sonar operator sound more glamorous to these people [in the US Navy]." As Hunt recalled in an interview more than twenty years later:

> Well, you need a name. So I sold him sonar. And Engelman wrote the letter which got passed up the line establishing sonar as the designation for underwater sound locating gear. Now, at the moment, the acronym escapes me—we had the word and then we invented the words from which it was to be derived. … Phonetically it was an analogue of radar. This is sound. This is sound radar. It's as simple as that. When you think sonar and you juggle with the syllables and what sells it is the fact that it is euphonious. And this I found is the key in coining words.[46]

As the British had their own acronym RDF for the American radar, so they had it for sonar. They called it for ASDICS, a term that appeared in public in 1939 possibly with ASD standing for *A*nti-*S*ubmarine *D*ivision and with the added -ics suffix signifying "pertaining to" (as in electronics or linguistics).[47] This term lived on until about 1950, after which it was replaced by sonar. Sonar may have been the first acronym that appeared with this designation in a regular scientific journal, namely the March 1948 issue of *American Journal of Physics*. The author was Gaylord Probasco Harnwell, a physicist at the University of Pennsylvania, who explained: "The physical properties of the sea determines the nature of SONAR (acronym for SOund Navigation And Ranging) which is the technic of submarine sound."[48]

Maser and Laser

The maser, a device for producing strongly amplified millimetre waves by means of stimulated emission in a beam of molecules, was a product of wartime radar science and technology.[49] Charles Townes, a physicist at Columbia University's Radiation Laboratory, conceived the idea of obtaining short microwaves from excited molecules in 1951 and three years later he and his collaborators Herbert Zeiger and James Gordon (who was Townes' PhD student) demonstrated the first maser or what they first called an "experimental device which can be used as a very high resolution microwave spectrometer, a microwave amplifier, or a very stable oscillator."[50]

The acronym "maser" from *m*icrowave *a*mplification by *s*timulated *e*mission of *r*adiation first appeared in a press release from Columbia University on January 20, 1955.[51] In a brief paper presented at a meeting of the American Physical

Society on May 1, Townes introduced the name to his physics colleagues and later the same year he, Gordon, and Zeiger published a comprehensive article in *Physical Review* with maser in its title: "The Maser—New Type of Microwave Amplifier, Frequency Standard and Spectrometer." As they wrote in the introduction: "We call an apparatus utilizing this technique a 'maser,' which is an acronym for 'microwave amplification by stimulated emission of radiation'."[52]

It is worth noting that the Gordon-Zeiger-Townes paper was probably the first time that a physics research article explicitly referred to the term "acronym," a term which by the mid-1950s was largely absent in scientific texts. Thus, a search for "acronym" in *Nature* 1940–65 gives only a single result, namely an article of 1958 that refers to "the recent developments in 'masers', an acronym formed by the initial letters of Microwave Amplification by Stimulated Emission of Radiation." Again, the term only turned up in *Science* three years later, characteristically in a news report referring to Townes as the originator of the maser.[53] In other words, Townes and his co-authors not only coined the term maser, they also pioneered the use of "acronym" in the physics literature. But as mentioned, they had been preceded by seven years by Harnwell's description of sonar.

Before settling on the term "maser," Townes referred to his apparatus with designations such as "molecular beam oscillator" or "molecular-beam emission spectrometer." Gordon later recalled about the naming of the maser:

> In April 1954, when five of us were having lunch in the Columbia teacher's college cafeteria, Charles Townes proposed that we name the coherent oscillator that we had just created. He vetoed any name that ended in "-tron." Before we left, we had created the name maser, an acronym for "microwave amplification by stimulated emission of radiation." Before long, Arthur Schawlow had re-imagined the maser acronym to mean "money acquisition schemes for expensive research."[54]

It is unknown why Townes did not want the oscillator to end with the suffix -tron, which at the time was used for a variety of physics instruments and known from, for example, cyclotron, dynatron, and magnetron. On the other hand, elementary particles like the electron and the neutron are -on and not -tron words (electr-on, neutr-on).[55] Townes' own recollections supplemented those of Gordon: "At lunch with my students …, I commented that we needed a name for the new device. We tried Latin and Greek names, but they seemed too long, so we settled on an acronym, based on the description: Microwave Amplification by Stimulated Emission of Radiation."[56]

Whereas the maser was a scientific apparatus with only limited use outside science, its further development into the laser became a great success also on the commercial and military markets. This well-known name was an acronym directly borrowed from the maser, only with 'light' substituting 'microwave.' The new acronym was coined by Richard Gordon Gould, one of several inventors of the

laser concept, who in a notebook of 1957, notarized on November 13, penned his thoughts about "Some rough calculations on the feasibility of a LASER: Light Amplification by the Stimulated Emission of Radiation."[57] He first used the term in public at a conference on optical pumping held in Ann Arbor in June 1959.[58] The same year he filed a patent application on "Optically Pumped Laser Amplifiers." Meanwhile, in late 1958 Townes and Schawlow published an important paper in *Physical Review* on "Infrared and Optical Masers" in which they presented the theoretical basis for the laser but without using the term. When Gould publicized the word laser, initially Townes and Schawlow were not much in favour of it:

> Maser was the basic device, and it seemed more orderly and systematic to label any variation simply as a kind of maser, such as an optical maser or an infrared maser. Most of our early papers used this terminology. However, laser was of course shorter and easier to say, and as the idea's popularity grew, the device eventually had to have a short name of its own.[59]

For a time, both before and after 1959, the laser was referred to as an "optical maser."

"Laser" was announced to the general public in a front-page article in the *New York Times* on July 8, 1960, and since then the term has become a household word.[60] According to *OED*, it is one of the 5,000 most common words in modern written English where it appears about three times more frequently than radar. It also appears in some other acronyms of which LIGO (*L*aser *I*nterferometer *G*ravitational-wave *O*bservatory) is probably the best known. The word laser is so commonly known that few will recognize LIGO to be a nested acronym with an initialism as part of another initialism. Another acronym of this kind is the LISA project for direct observation of gravitational waves with the letters standing for *L*aser *I*nterferometer *S*pace *A*ntenna. Moreover, among specialists the noun laser has been back-formed to a verb (to lase; also lased, lasing) with the meaning "to function as the working substance of a laser" or, for a device, "to operate as a laser."[61] The neologism appeared in print as early as 1962, if in a critical comment by a writer in *New Scientist* who did not like it at all. After having asserted that "on the whole science has done more to damage the language than to improve it," he or she continued:

> This is well illustrated by the uses now being made of the entirely novel verb "to lase" … [which] is common currency among those hardworking physicists … But to me it seems unforgivable that people should solemnly declare "it has lased" or "it won't lase". In my view every laboratory should be equipped with a machine consisting of a small laser which could be used for raising blisters upon the tongue of anybody who offended against decent usage in this manner.[62]

There are many earlier cases of back-formation of scientific terms into verbs, such as illustrated by atomize (from atom), electrify (from electricity), transistorize (from transistor), and pasteurize (from Pasteur or pasteurization).

Quasar and Pulsar

In the early 1960s astronomers identified a rare new kind of enigmatic celestial objects that emitted an enormous amount of electromagnetic energy in the radio region. Since the objects superficially looked like stars, they were called "star-like objects," "quasi-stellar radio sources," or "quasi-stellar objects" abbreviated to QSOs. According to the Dutch astronomer Maarten Schmidt, the principal discoverer of QSOs, at the 1963 Texas Symposium on Relativistic Astrophysics there was "half a session spent on finding a name for the confounded thing. And all the names had been unfortunate. Nobody liked any of the names proposed there."[63] Unfortunately we do not know what these names were. In May 1964 the quasi-stellar objects were renamed "quasars," an acronym formed by contraction of quas(i-stell)ar or quas(i st)ar. The name caught on and is today very popular not only in astronomy and physics but also beyond. It appeared in a book title with Fred Hoyle's *Galaxies, Nuclei, and Quasars* published in 1965.

The inventor of the neologism, the Taiwanese-American astrophysicist Hong-Yee Chiu, justified the name as follows:

> So far, the clumsily long name 'quasi-stellar radio sources' is used to describe these objects. Because the nature of these objects is entirely unknown, it is hard to propose a short, appropriate nomenclature for them so that their essential properties are obvious from their name. For convenience, the abbreviated form 'quasar' will be used throughout this paper.[64]

Although "quasar" soon came into general use, it took several years before the term was accepted and replaced the QSO acronym. According to a paper published in 1967, "The term *quasar*, proposed by H.-Y. Chiu, has been adopted by nearly everyone but the astronomers, who call these phenomena 'quasi-stellar objects'."[65] The editor of the leading research periodical *Astrophysical Journal*, Subrahmanyan Chandrasekhar, was among those who did not like the neologism. When Schmidt in 1970 wrote a paper in the journal with "quasar" in the title, Chandrasekhar added a note saying "The *Astrophysical Journal* has until now not recognized the term 'quasar'; and it regrets that it must now concede … [and that] the term can no longer be ignored."[66]

One of the few objections to "quasar" came from Nicholas Kurti, a distinguished Hungarian-born British professor of physics and a specialist in low-temperature physics. At a Royal Society conference in 1965, he expressed reservation with regard to "the disturbing rate of increase in new scientific and technical terms." As Kurti pointed out, "The very act of coining a new word implies a theoretical assessment, almost an acknowledgment of the fact that a

concept or phenomenon, or particle has a well defined identity." He suggested that, in general, when a neologism was justified, it should be "expressive, well-sounding and not too offensive to the purist." Kurti disliked acronyms and abbreviations or, as he expressed it, "telescoping of two words to save a few letters, or a syllable." This is where "quasar" came in:

> A good example is 'quasi-stellar,' which at least means something to a layman, changed to 'quasar.' Moreover, it seems that 'quasar' is used in the sense of 'quasi-stellar radio source' and this means that one uses the abbreviation of the adjective in the expression for the whole thing. To be logical one should either talk about 'quasar radio source' or about Quasars (singular, being the abbreviation of **QUA**si-**S**tell**A**r **R**adio Source). The latest cosmological abbreviation is Q.S.G. (quasi-stellar galaxy). Before long we may be talking about Quasarxies.[67]

Without using the term acronym—which in 1965 was not generally known among scientists—Kurti objected to "the use of initials and words formed from initials." He accepted "maser" and "laser," but these were exceptions:

> I think, however, that the use of initials to describe phenomena, instruments, apparatus, organisations in writing and in speech should be curbed. This practice results in the establishment of jargon and makes communication between laymen and specialists, even between specialists in different fields, more and more difficult. … I wonder whether the time and effort devoted to inventing descriptions whose initials fuse into well-sounding words, could not be better spent on finding short, apt expressions.

Other celestial objects with the -ar suffix followed the discovery of quasars, the first being the "pulsars" discovered in late 1967 by Anthony Hewish and his graduate student Jocelyn Bell (who married the following year and then became Jocelyn Bell Burnell). Like quasar, the neologism pulsar was a contraction of two words: puls(ating st)ar.

In their report to *Nature* in February 1968, Hewish and his research group referred to the peculiar object as a "rapidly pulsating radio source" or just a "radio source."[68] Shortly later Hewish was interviewed by Anthony Michaelis, a science correspondent of *The Daily Telegraph*, and it was during this interview that "pulsar" saw the light of day. It seems that the coining of the new acronym was originally suggested by Michaelis and then accepted by Hewish. According to Michaelis' article in *The Daily Telegraph*: "An entirely novel kind of star … came to light on Aug. 6 last year and, at first, … the star was referred to by astronomers as LGM (Little Green Men). Now it is thought to be a novel type between a white dwarf and a neutron [star]. The name Pulsar (Pulsating Star) is likely to be given to it."[69] During 1968 there appeared about two dozen papers with "pulsar" in their title. Contrary to "quasar," no one objected to the name.

In addition to quasar and pulsar, the astrophysical -ar family includes so-called "blazars," a kind of quasars with an origin in active galactic nuclei or what astronomers call AGN. The first example of this kind of variable radio object was originally thought to be a star located within the Milky Way and named BL Lacertae or BL Lac for short—or, even shorter, BLL. By the early 1970s such signals were recognized to be from extragalactic objects belonging to a new class of active galaxies. The present name dates from April 1978 and is due to the American astrophysicist Edward Spiegel, who formed it as a contraction of two known astronomical terms:

> In a memorable banquet speech at the Pittsburgh meeting on BL Lac objects … Ed Spiegel suggested the name 'blazar' for this class of object. A combination of BL Lac object and quasar, with a strong feeling of the characteristic violent optical flaring, blazar seems an excellent name, one which we will adopt.[70]

Other proposals of supermassive -ar objects include the "magnetar," the "blitzar," and the "spinar." The name of the magnetar, a rare type of neutron star proposed in 1992, derives from a contraction of magnet(ized neutron st)ar.

SQUID

To the extent that "squid" is known by the general public, it is probably from the fried culinary dish known as calamari prepared from squids, an abundant species of molluscs with eight arms and two long tentacles. However, to condensed matter physicists a SQUID (in capital letters) is an instrument based on superconductivity used for measuring small magnetic fields with extreme sensitivity. The device in the form of a so-called RF SQUID (RF standing for radio frequency) was invented in 1965 by a research group at the Ford Scientific Laboratory headed by James Zimmerman, but at first without using any special name for it.

> Zimmerman remembered that they began using the abbreviation 'QID' for 'Quantum Interference Device' but that he and [Arnold] Silver discussed the matter one day and agreed on 'SQUID' as an appropriate acronym for 'Superconducting QUantum Interference Device.' After that, they used 'SQUID' so routinely in conversations that the term was picked up by other groups. … Today, the term 'SQUID' can be found as an entry in the *Oxford English Dictionary*.[71]

In 1966, the acronym appeared unceremoniously in print: "A magnetometer utilizing a superconducting quantum interference device (SQUID) as a magnetic flux sensor is described."[72] It was just introduced as a convenient abbreviation and neither the authors nor other physicists noted that nature had invented squids millions of years ago. Since 1966 some 4,500 papers have been published with the physicists' acronymic SQUID in the title, which is almost as many as the papers on the biologists' non-acronymic squid.

Conclusion

Surprisingly, acronyms only entered the scientific vocabulary in the 1950s, at first hesitatingly but eventually explosively. A study of the rise and evolution of this phenomenon, and more generally of the changes in scientific language, provides a novel perspective of how the natural sciences developed in the second half of the twentieth century. The massive entrance of acronyms of all kinds was a trend shared by different branches of science that have here been examined with an emphasis on the physical and astronomical sciences from about 1950 to the present. Despite a sustained critique of excessive uses of acronyms, there is no indication that the number and frequency of acronyms in scientific articles is slowing down.

The formation of technical neologisms and acronyms is an integral part of the histories of how objects have been discovered, theories formulated, instruments designed, and organizations established in the late-twentieth century. This has been illustrated with a select number of case studies from physics and astrophysics of which Townes' invention of the maser is perhaps the most noteworthy. As pointed out, not only did Townes coin the acronymic term "maser," he and his collaborators also helped pioneering the scientific use of the term "acronym." More generally, the study of acronyms in science is only one example among many of how a focus on terminology and language can contribute to the historical understanding of how science has developed in the modern era.

Funding

Open access funding provided by Copenhagen University.

Data availability No such statement is relevant here.

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[45] *OED*, entrance 'radar.'

[46] American Institute of Physics, interview of January 8, 1965 by Leo Beranek and Charles Weiner, see https://www.aip.org/history-programs/niels-bohr-library/oral-histories. The word sonar is used in modern English about seven times less frequently than radar (*OED*).

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[58] R. Gordon Gould, "The LASER, Light Amplification by Stimulated Emission of Radiation," in *The Ann Arbor Conference on Optical Pumping*, eds. Peter A. Franken and Richard H. Sands (University of Michigan, 1959), 92.

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[61] *OED*. In what is called back-formation, parts of a word or group of words are removed to create a new term. Thus, the verb "to edit" was formed by removing "or" from the earlier noun "editor." There are similar back-formed words derived from the maser (to mase; mased, masing) which are mostly used in astronomy.

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Accepted 23 January 2024