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A BRIEF HISTORY OF RECREATIONAL PHYSICS

A discipline with a glorious past and a promising future

Rafael Garcia-Molina

One way of encouraging people's interest in physics is to provide them with rewarding experiences that stimulate their curiosity while simultaneously encouraging them to seek an explanation for the phenomena they observe. These experiences need to be related to the everyday environment to show that basic but far-reaching physical knowledge is accessible without the need for sophisticated equipment. To this end, recreational physics seamlessly blends science, entertainment, and outreach by incorporating experiments and games that appeal to people of different ages and educational backgrounds. In this article, we review the most notable works, authors, and activities in recreational physics to show how this discipline has evolved over the centuries and where it stands today.

Keywords: **recreational physics**, **history of physics**, **popularisation of physics**, **science entertainment**.

HOW A HOBBY BECAME A PASSION

My first contact with recreational physics was in my youth, when I was unaware of its relationship to my professional future. After long Christmas dinners, I would entertain my younger cousins by playing games or performing tricks with what was on the table. A balancing structure using a pair of forks, a cork, and a toothpick was a classic for some years, but then I was asked to expand my «repertoire». This led me to introduce a new tabletop distraction: an aluminium foil ball that rose and fell in a bottle of water at the will of the person performing the trick, which is no more than a simplified version of a Cartesian devil or diver. Later, my inventory was further expanded to include the challenge of maintaining five flat toothpicks in the air by holding only one, which was solved by forming a structure of crossed toothpicks; the game ended by setting fire to one corner of the set of toothpicks, which subsequently leads them to explode! These teenage pastimes are shown in Figure 1, along with 19th century pictures illustrating them.

As a teacher, I realised the enormous potential of this kind of science entertainment to get all sorts of people interested in physics. Since then, I have deepened my knowledge of the workings and applications of activities derived from recreational physics in order to better understand and communicate the fundamentals of my scientific discipline, and also for pure intellectual pleasure as a prelude to inquiry and understanding (Wagensberg, 2007).

«Recreational physics activities are easy to carry out, they do not use expensive equipment or complicated instruments»

Thus, I will now take you into the world of recreational physics to help you understand what it is, learn about its historical evolution through the documents and activities that have popularised it (especially in Spain), and review the historical origins of some experiences that are older than they seem.

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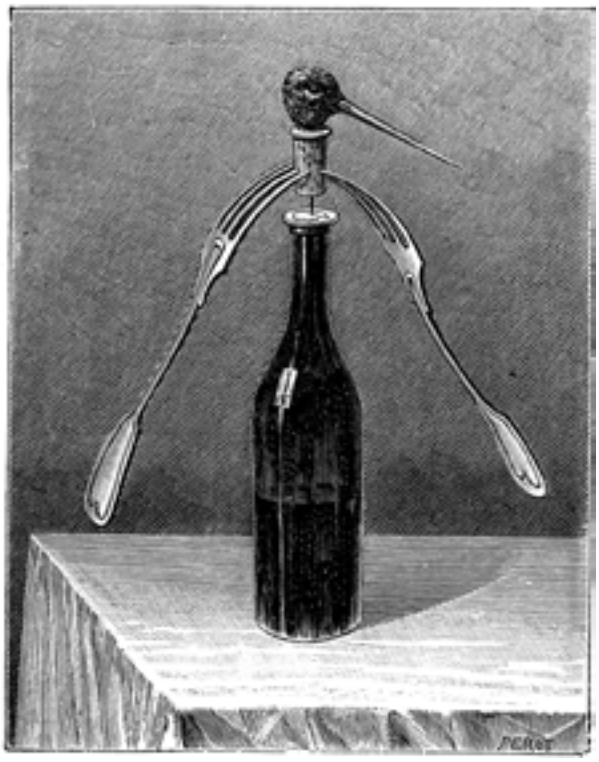

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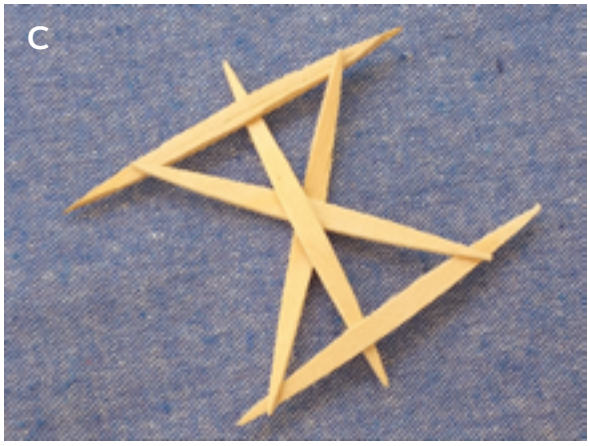

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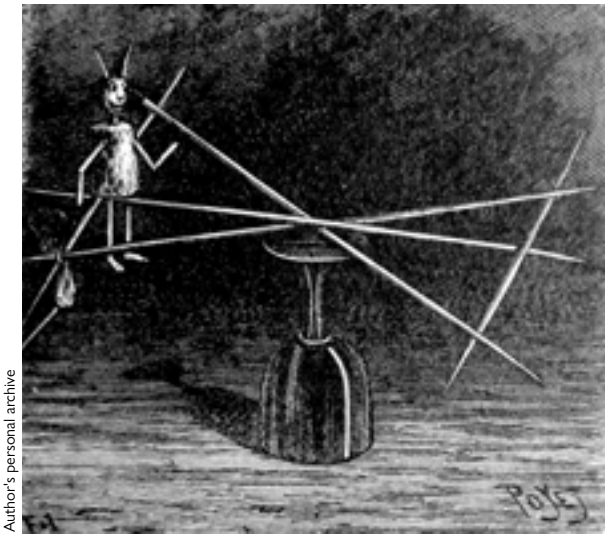

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Figure 1. On the previous page and above these lines, various recreational physics experiments: **A**) balancing forks, **B**) Cartesian diver, and **C**) toothpick structure. The upper and lower parts show, respectivley, the current versions of these experiments and their illustrations in 19th century books (**A** and **B** appear in the 3rd edition of *Les récréations scientifiques* by Gaston Tissandier, while **C** belongs to *La science amusante* by Tom Tit).

«Tissandier's *Les récréations scientifiques* presents simple scientific experiments that anyone can carry out at home»

WHAT DO WE UNDERSTAND BY RECREATIONAL PHYSICS?

There is no single, canonical answer to this question because recreational physics is not a specific field of work. Therefore, neither its content nor its modus operandi are clearly defined. What unites the texts that use the term recreational *physics* (or *science*, even if they focus mainly on physics) in the title is the fact that the activities they present are easy to carry out; they do not use expensive equipment or complicated instruments but rather, everyday utensils and materials available to everyone; are simple, fun, pleasant distractions and entertainments; are suitable for all audiences, without age or educational limitations; and are excellent educational tools that arouse interest in a discipline that, at first glance, may seem unattractive to the general public (Garcia-Molina, 2011).

A phrase borrowed from Martin Gardner (1998) would provide a shorter answer to the question in this section. Speaking about recreational mathematics, he said: «(...) math is considered recreational if it has a playful aspect that can be understood and appreciated by nonmathematicians». Here, we would only have to substitute the word *mathematics* for *physics*.

To summarise what we have discussed above, we could say that recreational physics is aimed at a non-specialist audience of no particular age with the goal of them having fun with these activities (i.e., enjoyment) and for them to carry out (re-create) scientific experiments themselves.

FOUR WORKS OF REFERENCE

Having reached this point, we must ask ourselves which books have contributed to the spread of recreational physics and have left their mark on everyone who has entered the field. Here I will highlight the four most important texts on recreational physics published since the end of the 19th century. They are considered important because of the number of editions and translations they have received and, above all, because they have set new standards for today's activities related to this subject. This, of course, is with the exception of those that require equipment or products derived from the technological advances of the last century. A brief biographical overview of these authors, in the chronological order in which they published their work, will help to contextualise their style and content.

We must begin with Gaston Tissandier (Paris, 1843 – 1899), author of *Popular scientific recreations in natural philosophy, astronomy, geology, chemistry*; Tissandier, 1880; Figure 2). This text, whose title

makes its content and purpose clear, presents simple scientific experiments that anyone can carry out at home. Indeed, considering the number of editions and languages into which it has been translated (Sablonnière, 2015), it can be considered the first highly successful book in recreational science. Many of its chapters are based on the column «Physique sans appareils» ('physics without apparatus') published in *La Nature*, a journal also founded by Tissandier in 1873. The author studied chemistry and was passionate about popularising science, particularly meteorology and aeronautics (he even escaped from the siege of Paris in a hot air balloon in 1870).

In addition to numerous works on meteorology, aeronautical navigation, photography, and practical science, etc., Tissandier also published a delightful scientific popularisation booklet for children entitled *Jeux et jouets du jeune âge* ('Games and toys for young children'; 1884). This booklet is notable for the exquisite illustrations by his brother, Albert, which show many of the experiments from *Les récréations scientifiques* in domestic and family settings (Figure 2).

Chronologically, the next author to dedicate his life to popularising science was Arthur Good (Montivilliers, 1853 – 1928), an engineer by profession. Better known as Tom Tit, as he signed his books, he wrote a series of articles in the weekly publication *L'Illustration*, entitled «Scientific amusements». In his articles, he presented scientific experiments (mainly in physics) that could be reproduced using everyday materials (e.g., bottles, glasses, spoons, and forks, etc.). He collected these little experiments in three volumes under the same name as his weekly column (Tom Tit, 1890, 1892, 1894), which were all very well received by readers. The books ranged from «simple games for the amusement of the family» to experiments «of a truly scientific nature». Figure 3 shows Arthur Good himself on the cover of the second volume of *La science amusante*, doing one of the activities proposed therein. Images from these books were widely reproduced in scientific popularisation and educational texts (especially in the first half of the 20th century). Among the other books by Arthur Good, in which he combined handicrafts with the popularisation of science, *La récréation en famille* ('Family recreation'; 1903) stands out.

The enormous success of Tom Tit's work – and its numerous reprints and translations – is evidenced by several collections of prints and advertisements based on the experiments of *La science amusante* (Figure 3).

«Images from Tom Tit's books were widely reproduced in scientific popularisation and educational texts»

The third author is Yakov Isidorovitch Perelman (Białystok, 1882 – Leningrad, 1942), who studied forestry in Saint Petersburg but never practised it because he began to work in the field of scientific popularisation while he was still a student. In 1913, he published *Physics for entertainment* (Figure 4), which was well received by his fellow citizens, even in the academic world. This was not only because of the topics it covered, but also because of its informal, informative style, which combined scientific matters with literary and historical references and anecdotes, etc. After the Russian Revolution, Perelman devoted himself to popularising and teaching science, renewing educational programmes in physics, mathematics, and astronomy. In the 1920s he published a new volume of *Physics for entertainment*, which greatly expanded the number of physics experiments already published.

Problemas y experimentos recreativos ('Recreational problems and experiments') was published in Spain in 1975 and contained many physics experiments. However, I have not found any antecedent of this publication published during Perelman's lifetime and so I suspect that it was a compilation of scattered works by this author that was prepared by the Mir Publishers. This work included experiments clearly inspired by what Tom Tit had done years earlier, like the ones shown in the collectable cards in Figure 3. In addition to this book and the two volumes of *Physics for entertainment*, Perelman wrote many popular science texts and school manuals, among which *Mathematics can be fun*, *Arithmetic for entertainment*, and *Astronomy for entertainment* stand out.

Finally, let us conclude this section with Josep Estalella i Graells (Vilafranca del Penedès, 1879 – Barcelona, 1938). He studied physics and chemistry at the University of Barcelona, where he worked as a professor and obtained his doctorate in 1902. In 1905 he joined the Secondary School of Girona, where he obtained the Chair of Physics and Chemistry. In 1919, he moved as a professor of physics and chemistry to the Instituto-Escuela of Madrid (which depended on the Junta para Ampliación Ampliacion de Estudios e Investigaciones

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Figure 2. On the left, the cover of the 4th edition of *Les récréations scientifiques* by Gaston Tissandier, published in 1884. On the right, an illustration by Albert Tissandier (Gaston's brother) included in the book *Jeux et jouets du jeune âge* (1884). It shows a beautiful version of the diver, in the form of a priest, and a set of water pumps to feed several «home fountains», which, among other things, support a Chinese figurine that deforms the upper part of the water jet into the shape of an umbrella. Note the similarity between this scientific amusement activity for children and the dancing eggs shown.

MÈTODE

Figure 3. On the left, the cover of *La science amusante* (*Deuxième série*), published in 1892. On the right, collectable cards showing two children carrying out experiments from *La science amusante*.

Cientificas) of which he became director in 1921. However, a few months later he had to resign because of his father was ill and so he joined the Secondary School of Tarragona. From 1932 until his death, he was director of the Institut-Escola de la Generalitat de Catalunya, located in Ciutadella Park in Barcelona.

Estalella stood out for his contributions to the teaching of physics and chemistry, influenced by the pedagogical movements of the time. His classes were practical, he encouraged active student participation and motivated and guided them to work, using everyday materials available to or made by the students, without requiring expensive equipment.

At the end of his stay at the Secondary School of Girona, Estalella published the book *Ciencia recreativa* ('Recreational science'; Estalella, 1918), the cover of which is shown in Figure 4. More than half of the almost 1000 activities it contains are related to physics. Most of the proposed activities are presented directly (without a preamble contextualising the activity) and are accompanied by illustrations. Although a significant part of the content of *Ciencia recreativa* coincides with what could be found in the reference books already discussed, the author contributed some original items, indicated by the letter *E* (his surname initial). Estalella also wrote articles in the Spanish scientific journals of the time and was the author, co-author, and translator of several technical books.

Moreover, in 2007, the Barcelona City Council and the Seneca Foundation of the Region of Murcia independently published an annotated edition of *Ciencia recreativa* in which several authors reviewed and explained the content of Estalella's work from a contemporary perspective.

In addition to a handful of experiments and illustrations (with slight variations), all the recreational physics books I have mentioned in this section have the use of toxic, corrosive, or sharp materials in common. They also share a gender bias in the distribution of experiments: while boys are the protagonists of challenges and exercises of strength or dexterity, etc., girls are seen to participate in children's activities or games of patience or are mere observers of what the boys are doing. Finally, I must also point out that the explanations of many phenomena also contain misconceptions. This is the case with centrifugal force (which does not exist as such), the transfer of heat (as if it were a substance contained in bodies), the relationship between the decrease in the speed of the air and the increase in atmospheric pressure (in situations where the Bernoulli equation cannot be applied), and some other cases where a detailed explanation would require a more thorough analysis.

Nonetheless, these criticisms (similar content and illustrations, gender bias, and conceptual errors) must be understood in the context of the era in which the books were published. What is more concerning is that some of these «defects» are still reproduced in current texts.

BEFORE AND AFTER THE GOLDEN AGE

The books we have mentioned so far belong to the second period in the development of treatises on recreational science, as proposed by Jordi Pablo (1981). This period, which stretched from the middle of the 19th century to the first third of the 20th century, was characterised by the appearance of scientific journals with a large circulation and abundant, high-quality illustrations. These gave rise to several books on scientific dissemination and recreational science, such as those mentioned above.

Apart from this period (which in my opinion could be called the «golden age»), two other periods also made a remarkable contribution to recreational science. The earlier period was from the Renaissance to the middle of the 18th century, while the later, third period, started around the time of the Spanish Civil War. We will now discuss the most interesting contributions to recreational physics from these two periods.

«Many of the recreational physics books from the 19th and 20th century have the use of toxic, corrosive, or sharp materials in common»

The books from the first period are characterised by the presence of many «magical» recipes for casting spells, as well as games of wits and parlour tricks. The latter were based mainly on using dice and card decks (mathematics), but also on mechanics, optics, electricity, and magnetism (physics), or pyrotechnics and transmutation of the elements (chemistry). Some outstanding works from this period include *Récréation mathématiqve* ('Mathematical recreation'; Leurechon, 1624), published in 1624 by the Jesuit, Jean Leurechon (Bar-le-Duc, 1591 – Pont-à-Mousson, 1670). This was the first book to mention the word «recreation» in its title (Heeffer, 2006) although only in reference to mathematics, despite also containing a substantial section devoted to physics.

In 1694, Jacques Ozanam (Bouligneux, 1640 – Paris, 1718) published *Recreations in mathematics and natural philosophy* (Ozanam, 1694). As was usual at the time, the work was based on that of previous authors (including Leurechon), but because of its direct style and broad content, this text can still be considered the forerunner of recreational science books. It was a kind of scientific encyclopaedia, presenting subjects related to mathematics, mechanics, optics, acoustics, astronomy, architecture, pyrotechnics, magnetism, electricity, and chemistry, etc. in the form of problems. Originally published in two volumes, the most famous edition was published in 1778 and was corrected and enlarged by Jean-Étienne Montucla (Lyon, 1725 – Versailles, 1799), and influenced an entire generation of science disseminators (Càndito, 2016).

In the second era of recreational science treatises, in addition to the reference books mentioned above, other books were also published in Spain, such as those using recreational physics resources in magic shows, daily activities, and teaching. Among these was *Magia y física recreativa* ('Magic and recreational physics'; Robert-Houdin, 1887) by Jean Eugène Robert-Houdin (Blois, 1805 – Saint-Gervais-la-Forêt, 1871), considered the father of modern magic. This volume, which contains numerous illusionist tricks based on the author's knowledge of optics, mechanics, electricity, and acoustics, etc., is an example of many other publications that included the words «recreational physics» in their titles (Sim Sala Bim, n.d.).

Recreational physics applied to everyday life has a clear exponent in *Ciencias y paciencias del calaix d'un sabi* ('Sciences and patiences of a wise man's drawer'; sic), where experiments are mixed among illustrations copied from the second volume of *La science amusante* (but having erased the engraver's signature). These are presented alongside curiosities about games, diversions, formulas, and household remedies and was compiled by Fra Noi (n.d.), the pseudonym of Josep Burgas i Burgas (Barcelona, 1876–1950). In the same vein of providing domestic resources, but this time explained with more scientific rigour, is the book *Les ciències en la vida de la llar* ('Science in the life of the home'; Sensat de Ferrer, 1923), written by the pedagogue Rosa Sensat i Vilà (El Masnou, 1873 – Barcelona, 1961), which provided women with technical knowledge to keep the home tidy.

Other books from this period, simply titled *Física recreativa* ('Recreational physics'; Estrada, 1935; Yesares Blanco, n.d.), seems to have been designed to incorporate recreational physics experiments into the classroom. However, these activities appear in almost an anecdotal form, relegated to supplementing explanations in the purest academic style; they are long and erudite (and sometimes even erroneous). These two books are an example of the laxity in publishing new titles on recreational physics at the beginning of the

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Figure 4. On the left, the cover of *Physics for entertainment* by Yakov Perelman, in the Russian edition from 1935. On the right, the cover of *Ciencia recreativa*, by José Estalella.

«Easier access to new materials and a critical rethinking of some classic experiments have led to a revival of recreational physics»

Spanish Civil War. It was not until the end of the 20th century, and especially at the beginning of the 21st, that the public interested in these subjects was able to enjoy new content, as we will see below.

THE RECREATIONAL PHYSICS REVIVAL

After the Spanish Civil War there was a long period without any new publications on recreational physics. Public interest in the subject survived, however, as evidenced by the final scene of the film *Welcome, Mr Marshall!* (1953) when, like all the other inhabitants of the town, the doctor gives up his «recreational physics» machine with which he had hoped to impress the American visitors. Nonetheless, new publications on the subject only appeared a few decades after the end of the war, in the form of translations of foreign works by authors who had continued to collect classic experiments together in compendiums.

Finally, in the last third of the 20th century, Mir Publishers, the editorial in Moscow, published a Spanish translation of the two volumes of *Physics for entertainment* by Y. Perelman (1968 – 1969), which was later republished by the Barcelona editorial Martínez Roca. This publication gave the author of this current article (alongside many others) access to a vast repertoire of experiments, phenomena, and amusements, etc. inspired by recreational science, which were useful both at family gatherings and in the classroom (Averbuj, 1986).

Of particular importance was the appearance, in 1976, of *Investigación y Ciencia*,[1] the Spanish version (with slight variations on the original) of *Scientific American*. This monthly journal included a section called «Taller y laboratorio» (the Spanish adaptation of «The Amateur Scientist», published since 1928), which dealt with more sophisticated topics and equipment than those traditionally considered in popular science books of the time, while still keeping in their spirit. These columns considered intriguing and entertaining topics, using elementary and reproducible scientific concepts and materials that were relatively easy to obtain and manipulate. The monthly availability of this section, together with the publication in 1979 of the Spanish translation of *The flying circus of physics* by Jearl Walker (1977), who headed up «The Amateur Scientist» in the year *Investigación y Ciencia* started, triggered a renewal in the approach to and content of recreational science activities. *The flying circus of physics* presented problems and experiments related to everyday life in settings that were familiar to the reader.

In the year 2000, the Física en Acción ('Physics in Action') competition was first held in Spain in San Sebastián. It brought together a selection of physics teachers and popularisers who went on to take part in the European project «Physics on Stage», held at the CERN facilities in November 2000 (Figure 5). These two competitions continue to this day (and are now known as Ciencia en Acción – 'Science in Action' – and Science on Stage). The first edition of these competitions, especially the European one, helped popularise recreational physics activities among a latent audience whose interest had been discreetly brewing in the latter years of the 20th century. The fruit of these competitions are the science fairs currently held all over Spain (*Madrid es Ciencia*, *Semana de la Ciencia y la Tecnología* in Murcia, *Experimenta* in Valencia, *Ciència al carrer* in Lleida, *Festa de la Ciència* in Barcelona, and *Setmana de la Ciència* in Catalonia, etc.), where students

[1] Sadly, the journal ceased publication in 2023 because of financial difficulties and its valuable historical archives are currently inaccessible.

and teachers, in perfect symbiosis, present ingenious recreational experiments involving physics and other scientific disciplines. The preparation, staging and enthusiasm with which those involved communicate their recreational science activities to society bodes well for the future of recreational physics (and science in general).

FOLLOW THE TRAIL, FIND THE HARE

Some of the most popular recreational physics activities have a long history. Here I will mention just two common experiments and one that went viral on social media.

The first was the Cartesian devil or diver mentioned at the beginning of this article. This is a hollow glass figure with a small hole through which water can enter and exit, which is placed inside a bottle of water. When the bottle is squeezed, the water enters through the hole and the figure sinks like a diver. Its operation had already been described in Ozanam's book, but it was one of Galileo's disciples, Raffaello Magiotti (1648), who presented it as a *scherzo* of his own invention. Magiotti claimed that the rise and fall were not because of temperature but rather, the result of air compression, making this latter distinction to separate his invention from the so-called Galileo thermometer (invented by A. Kircher in 1654). In the latter, glass chambers filled with liquid rise and fall in a tube filled with ethanol in line with the ambient temperature (Carrasquer et al., 2013). Nonetheless, the Cartesian diver toy was mistakenly attributed to Descartes (hence its name), who called it a *ludion*.

In the second experiment, a flame descends the vapour of a wax or paraffin candle that has just been extinguished. The candle fume experiment is traditionally attributed to Michael Faraday (1861), however, it was known at least six centuries earlier, as the following text from the third book («Which treats of the Heavens») of *Felix* (Llull, c. 1290/1985) attests:

> "My friend", said Felix, "the stars traveling through the air – what are they?"
> The shepherd replied, "It once happened, when I was a student of theology and philosophy, that the light from a lit candle traveled down the smoke of a snuffed-out candle, which light, burning the humidity, along with the cold and dryness, of the smoke moving next to it, traveled downwards and lit the candle."

The Llull scholar A. Bonner confessed to me that he had never understood the mechanism Llull was referring to in this paragraph until I explained it to him (Bonner, 2013).

CERN

Figure 5. Poster for the first Physics on Stage competition, held at CERN from 6 to 11 November 2000.

Thirdly, we discuss the so-called finger lift game that became a viral challenge based on a scene from the film *The craft: Legacy* (2020): a few people can lift another person (either standing or sitting) using only one or two fingers placed under the armpits or knees of the person they want to lift. This does not require much strength but rather, good synchronisation between the participants so that they all exert their effort at the same time. This can be achieved in several ways. The first surviving written reference to this activity is an entry in Samuel Pepys' diary (1825) from 1665, in which he tells the story behind the following song: «Voici un corps mort / Raide comme un bâton / Froid comme marbre / Léger comme un esprit / Levons te au nom de Jesucrist.»[2]

Pepys writes that a Mr. Brisband explained to him that in Bordeaux he had seen «four girls, all very young, each kneeling on one knee; one saying the first line, and whispering in the ear of the next, and the second in the third, and the third in the fourth, and this one to the first. Then the first began the second line, and so on for all the lines, and putting only one finger each under a boy who was lying on his back on the ground as if he were dead, after the words they raised this child as high

[2] «Here lies a dead body / stiff as a stick / cold as marble / light as a spirit / rise in the name of Jesus Christ.»

as they could with their four fingers». In this case, the systematic repetition of a series of words helped the four girls to use their fingers in a synchronised way to lift the volunteer who was lying on the floor.

Surely there are other similar leisure physics experiences and experiments with a long history behind them. Documenting their origins is an interesting task for historians of science.

BOTTOM LINE: LONG LIVE RECREATIONAL PHYSICS!

The development of recreational physics activities has gone through several stages since the first documents mentioning them were published. The simple description of challenges, parlour games, or tricks (sometimes related to magic shows), typical of the writings of the 17th century, evolved into the vindication and dissemination of physics concepts through small experiments intended as family entertainment. These all had a certain educational purpose, in line with the style of 19th century publications. The simultaneous use of physics knowledge by the magicians of the time also contributed to expanding the repertoire of recreational physics experiments. The activities from this period were most popular throughout the 20th century and have survived to the present day. However, easier access to new materials and a critical rethinking of some classic experiments (enriching them or correcting erroneous explanations) since the middle of the 20th century, and especially contemporaneously, have led to a revival of recreational physics. The field has attracted not only those who enjoy experimenting at home, but also teachers – who can integrate recreational physics activities into their teaching practice from primary school up to university level – and researchers, who can analyse old recreational physics experiments, correct long-held misconceptions, and generate new proposals.

At this point, if any readers are not yet convinced of the value of recreational physics (in any field), all that remains is for me to invite them to open any of the books we have discussed above and choose (randomly, if they so wish) an experiment to perform in front of family, friends, or students, etc. If they do it right, which may take some practice, they will understand the seductive power of a simple experiment accompanied by a good presentation!

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