East Asian Science, Technology and Society: An International Journal (2018) 12:235–256
DOI 10.1215/18752160-6976023

# Coping with Invisible Threats: Nuclear Radiation and Science Dissemination in Maoist China

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Received: 12 August 2016 / Accepted: 18 December 2017


**Abstract** During the early People's Republic of China (PRC) era the science dissemination campaign (*kexue puji*) aimed at conveying not only scientific knowledge related to daily life concerns but also knowledge about invisible dangers, most prominently those emanating from weapons of mass destruction such as nuclear weapons. The immediate task of the young PRC after the outbreak of the Korean War in 1950 was to make nuclear radiation visible by iconic metaphors and to teach the population about the dangers of an invisible nuclear fallout should the United States decide to use nuclear weapons. By focusing on the most characteristic media in science dissemination of the 1950s such as the *Newsletter of Science Dissemination* (*Kexue puji tongxun*), as well as popular science journals such *Science Pictorial* (*Kexue huabao*) and *Knowledge Is Power* (*Zhishi jiushi liliang*), this article shows how the state used metaphors of the invisible to influence social and political behavior. Convincing the barely literate peasant and the inchoately educated worker of possible dangers in the Cold War required a different epistemology of knowledge than in traditional society. This resulted in a further refinement of Maoist science philosophy that integrated materialism into science policies.

**Keywords** history of science · Maoist China · knowledge production · historical materialism · epistemology of science and knowledge · science dissemination · propaganda

**Acknowledgments** I express my gratitude to Theresa Pfeifer for searching graphical representations of nuclear radiation, Stefan Landsberger for providing me with precious posters, Michael Schoenhals for sending me obscure police reports on nuclear accidents in the Cultural Revolution, and especially the anonymous reviewers for their valuable comments. The insights on the institutions of science dissemination stem from my collaboration with Rui Kunze, with whom I pursued an earlier research project titled *Science, Modernity and Political Behavior in Contemporary China (1949–1978)*. I thank the Chiang Ching-Kuo Foundation for its financial support of this project (RG007-U-12) that laid the foundation for this article.

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The introduction of historical materialism to China in the twentieth century fundamentally changed the understanding and function of science and technology in Chinese society. Supported by the Marxist telos of history, development and progress were soon no longer seen as contingent but under human control and thus projectable into the future. Materialism provided humankind with an "objective" law that served as a guide to correct knowledge and practice. Arguing that man was actually able to comprehend his environment, make feasible observations, and test his hypothesis, this materialism generated a scientific optimism that many scholars have identified as central to Chinese modernization discourse (Fröhlich 2000; Kwok 1965; Lee 1973; Suttmeier 1980; Yu 2013).

The direct link between science and modernization was politically recognized in Maoist China as early as November 1949 when the Bureau of Science Dissemination was founded under the leadership of the Ministry of Culture of the Central People's Government (Zhongyang renmin zhengfu wenhuabu kexue pujiju 中央人民政府文化部科学普及局). Starting in the following month it published the *Newsletter of Science Dissemination* (*Kexue puji tongxun* 科学普及通讯) that understood science dissemination as "disseminating natural scientific knowledge," whose goals well transcended the arena of natural science: "To propagate materialism and to enable the laboring people to grasp techniques and technology for production as well as the rules of natural development so that they are qualified for the tasks of national [economic] production and construction" (Kexue pujiju 1950: 7).

In this context, to think and act scientifically primarily meant fighting superstition (*mixin* 迷信) as Xu Liangying 许良英 (1920–2013) and Fan Dainian 范岱年 (born 1926) emphasized in their 1957 book *Kexue he woguo shehuizhuyi jianshe*.[1] The great bulk of popular science literature in the 1950s and 1960s shared this line of argument in spreading the idea of people's science (*renmin kexue* 人民科学).[2] Its keynote had been set in 1941 by the oversimplified definitions of natural science by Mao Zedong 毛泽东 (1893–1976) as "the weapon to explain and conquer nature" (Mao 1941). Controlling and shaping the natural world according to human needs made perfect sense to Maoist thinking, represented most prominently in the famous parable "The Foolish Old Man Who Removed the Mountains" (*Yugong yishan* 愚公移山).[3]

It should be noted that Mao's definition of science precluded the "metaphysical world view" (*xing'ershangxue de yuzhouguan* 形而上学的宇宙观) of the bourgeois class. Instead, he called for using dialectical materialism to remove anything "unscientific" so that natural science can be reformed into "pure science" (*chedi de kexue* 彻底的科学). The tautology tied natural science with materialism, and it created a break with earlier conceptions of *kexue*. For Mao, its correct version primarily meant to have the correct epistemology of knowledge: "Rational knowledge depends upon

[1] An English translation of this work appeared in 1982; for their arguments against *mixin* see Xu and Fan 1982: 66, 69.

[2] The term appeared for the first time in the early 1950s, e.g., Gao 1951. Exemplarily booklets condemning superstition include *Pochu mixin wenda* 1964, Sun Wu 1964, *Tantan pochu mixin* 1963. For an overview on the fight against superstition in China since the late Qing, see Bruun 2003, Nedostup 2009, and Smith 2006.

[3] Presented for the first time by Mao Zedong in his concluding speech at the Seventh National Congress of the Communist Party of China on 11 June 1945, this text became in 1966 one of the "three frequently-read articles" (*Laosanpian* 老三篇). For the parable see *Mao Zedong xuanji* 1967, 3:1049–52; English translation in *Selected Works of Mao Tse-tung* (1977, 3:271–74).

perceptual knowledge and perceptual knowledge remains to be developed into rational knowledge—this is the dialectical-materialist theory of knowledge. In philosophy, neither 'rationalism' nor 'empiricism' understands the historical or the dialectical nature of knowledge," as he wrote in his 1937 text *Shijianlun* 实践论 (*On Practice*).[4] Scientific knowledge is ideally derived from workers' and peasants' practical experiences, expecting them to make a contribution to the realization of progress. While this paradigmatic change was caused by revolutionary zeal and the fight for correct class consciousness, it simultaneously enforced mistrust toward pure expert knowledge, that is, knowledge not based in social practice.[5] In a truly revolutionary society, science could no longer be made in the ivory tower but had to valorize knowledge of the working masses, as the chairman had postulated in his 1942 *Zai Yan'an wenyi zuotanhui shang de jianghua* 在延安文艺座谈会上的讲话 (*Talks at the Yan'an Forum on Literature and Art*).[6]

Accordingly, when the Communist Party of China took power in 1949, state policies were quickly formulated that aimed at putting the new notion of science into revolutionary practice. Analyzing a variety of science dissemination materials, Sigrid Schmalzer shows in her book *Red Revolution, Green Revolution: Scientific Farming in Socialist China* (2016) that the state strove to combine local and foreign knowledge and emphasized practice over theory to empower the peasant according to the logic of "mass science" (see also Matten and Kunze 2017). With regard to the Chinese typewriter, Thomas Mullaney (2012) points out that it was the typist who contributed to its radical innovation because the technology to be improved was haptically, or empirically, accessible for the typist and resonated with myriad personal pathways in adapting to technosomatic conditions. It resulted in typewriter tray beds that were refined by an endless individualization and personalization achieved by nonexperts, thereby facilitating its almost unbelievable rise in efficiency. Knowledge derived from experiential wisdom is similarly lauded in the case of earthquake prediction. According to the findings of Fan Fa-ti (2012), the Chinese efforts to do so during the Maoist era relied less on understanding or applying sophisticated geophysical models of seismicity than on correlating precursory phenomena such as unusual animal behavior with possible immediate earthquakes. This approach was believed to function for two reasons: it was phenomenological, and it facilitated mass participation in identifying strange occurrences. At the same time, Chinese seismologists were able to draw on an unprecedented set of earthquake records in historical documents, thereby enriching techniques such as seismic mapping and measuring electromagnetic fields with empirical data.

4 See *Mao Zedong xuanji* (1967, 1:268); English translation in *Selected Works of Mao Tse-tung* (1977, 1:303–4).

5 Recent publications in the field of STS have in a similar fashion emphasized the role of "lay expertise" (Wynne 1996; Epstein 1996), thereby paralleling Mao's critique of the predominance of "bourgeois" experts educated in foreign countries and his preference for the revolutionary creativity of the masses instead (Whyte 1973; Schmalzer 2016).

6 See *Selected Works of Mao Tse-tung* (1977, 3:69–98). Two years earlier Mao required intellectuals to join the united front. In his *On New Democracy* (1940) he argued that "new-democratic culture is scientific. Opposed as it is to all feudal and superstitious ideas, it stands for seeking truth from facts, for objective truth and for the unity of theory and practice. On this point, the possibility exists of a united front against imperialism, feudalism and superstition between the scientific thought of the Chinese proletariat and those Chinese bourgeois materialists and natural scientists who are progressive" (*Selected Works of Mao Tse-tung* 1977, 2:381).

These examples show that the mass science approach emphasized the significance of empirical matter that anyone can observe visually, grasp manually, and experience physically. It was vital for the science dissemination movement of that era (as argued by Schmalzer 2008) to replace wrong idealist beliefs with scientific knowledge based on materialism (so that lightning and thunder were no longer seen as signs of the gods), instead of removing ignorance by filling a knowledge vacuum in a top-down fashion (Michael 2003).[7] Building on the insights of Schmalzer, here I argue that in order to successfully popularize science, it was in many cases deemed necessary by state institutions to visualize the unknown. In fact, science dissemination periodicals—either continued from the Republican period or newly established in 1949—increasingly relied on pictures, photos, and drawings. Prominent journals of that era were the *Kexue huabao* 科学画报 (*Science Pictorial*, 1933–), *Kexue puji tongxun* 科学普及通讯 (*Newsletter of Science Dissemination*, 1950–51), and *Zhishi jiushi liliang* 知识就是力量 (*Knowledge Is Power*, 1956–63).[8] Instead of taking these journals as mere channels of state propaganda, I show how they rely on empirical and visual evidence in defining what counts as scientific knowledge and what does not. This was to become the true impact of Maoist *kepu*, or science dissemination, that justified itself by a direct reference to materialist epistemology, no matter if the matter at hand was tangible or not.

The following case may serve as an example. When optical instruments as means for enhancing the human visual sense were introduced on a large scale in Republican China (1912–49) as part of biomedical sciences, it became possible to identify bacteria as the major culprit in communicable diseases. This insight helped advance hygiene and improve national health decisively in urban China (Rogaski 2004; Lei 2014). When the Communist regime started its Patriotic Health Campaign in the early 1950s, the greatest obstacle was indeed to convince peasants with low literacy and little exposure to natural sciences that bacteria caused diseases. According to Miriam Gross (2016: 92–97), the microscope was the preferred medium of conveying scientific knowledge on the invisible pathogens, yet it failed because there was no shared knowledge base of the science disseminators and their rural audience—unless the demonstration of snail fever larvae was combined with intensive science tutoring and increased literacy.[9]

While biological pathogens could be visualized and their dangerous potential—at least in principle—could be communicated, the case for another much smaller yet far more fearsome matter looked differently. When the Korean War broke out in 1950, the risk of a nuclear attack on and beyond the peninsula grew, pushing the Chinese government promptly to explain the danger of nuclear radiation to its people. Discussions in prominent *kepu* periodicals of the 1950s emphasized that this was politically imperative to avoid resignation and loss of revolutionary zeal during the socialist construction

[7] On the role of ignorance in science, see also Firestein 2012.

[8] Launched by the Science Society of China in 1933, *Kexue Huabao* was taken over by the Shanghai branch of the All China's Association for the Dissemination of Scientific and Technological Knowledge in 1953. *Kexue Puji Tongxun* was published by the Bureau of Science Dissemination under the Ministry of Culture and renamed in 1951 as *Kexue puji gongzuo* 科学普及工作 (*Science Dissemination Work*). *Zhishi Jiushi Liliang* followed the style and ideas of its Soviet namesake *Знание-сила.* Its editorship included the All China's Association for the Dissemination of Scientific and Technological Knowledge and the Ministry of Labor. The central committee of the Communist Youth League joined in 1957, indicating the task of the journal to shape new generations.

[9] On the early acceptance of the microscope in late imperial China, see Lei 2010.

campaign.[10] This made it necessary, though, to develop sophisticated solutions for visualizing the intangible in such a way that they neither contradicted the Maoist knowledge epistemology nor were incomprehensible to the nuclear physics layperson.

## 1 Approaching the Invisible Atom

In her article "Popular Responses to the Atomic Bomb in China 1945–1955," Henrietta Harrison points out that though the atomic bomb explosions in Hiroshima and Nagasaki were reported quickly in Chinese media, they were scarcely seen as events raising global fears. Rather, after learning about the bomb mainly via translations of American and European reports the state propaganda purported during the 1950s the advantages of atomic energy in the modern age. It was idealized as a never-ending source of energy that can be used for improving living standards and conquering nature, thereby turning the "apocalyptic fear to scientific fantasy" (Harrison 2013: 99).[11] These promises, however, not only were characteristic of socialist states that based their political legitimation on their unshakable faith in historical determinism (thus also the Soviet fascination with nuclear energy; see Josephson 1999) but could also be found in the United States. In the 1950s, influential media to strengthen such faith were films and cartoons. Walt Disney's *Our Friend the Atom* (1957), an episode of the television series *Disneyland* produced on behalf of the American government, claimed that the atomic genie would forever be humankind's friend. The film painted a highly optimistic picture of how atomic energy will transform the fate of humanity without discussing possible dangers or necessary precautions (except the warning against a nuclear war at the end). Even US Civil Defense films such as *Survival under Atomic Attack* (1951) and *Duck and Cover—Bert the Turtle* (1951) that taught how to prepare for survival in the case of an atomic attack were held in a similar optimistic mood, arguing that adequate knowledge prevented an attack developing into an apocalypse.

In contrast to Harrison's paper, which focuses on how the Chinese government tried to remove fears of the bomb among the people by transmitting information on the atom and nuclear radiation through transnational layers shaped by powerful political interests, the aim of this article is to show in what way knowledge on nuclear radiation was communicated to those circles in Chinese society that did not possess the necessary equipment for detecting and thereby proving empirically the presence of radiation. Understanding the nature of atoms and radiation was key to making nuclear power serve the cause of socialism without fearing it. This made it mandatory to render the nature of the nuclear visible, similar to the case of the bacteria. Admittedly alpha, beta, and gamma radiation cannot be tasted, touched, smelled, or seen. It can make things visible (in case of ionizing radiation such as x-rays), yet itself remains invisible, and thus its danger is more frightening.[12] When Bertha Röntgen (1839–1919) was shown an x-ray of her own hand bones in 1895, she declared that she had seen her own death.

[10] See here numerous contributions on the atomic bomb in the *Kexue Puji Tongxun*.

[11] On the coexistence of atomic hopes and nuclear fears in the Cold War era, see Weart 2012.

[12] Although x-rays are not radioactive but electromagnetic radiation, in common perception this differentiation is seldom made. It is their invisibility that makes them fearsome, a circumstance that in the case of intercontinental ballistic missiles, which are stationed underground, is even more prominent.

Modern science seemed to create more dangers than protecting man from them (especially if one recalls that even a little dose of radiation can prove fatal), even though it was shining into every corner of the world.[13] It became obvious that "learning how to keep safe in the presence of silent, invisible, and impalpable dangers is . . . a commonplace, a challenge of modern life" (Parr 2006: 821; see also Johnston 2011). As put by John O'Brian (2015: 77), nuclear radiation possessed in this context a different quality from that of the well-known consequences of environmental damage caused by ruthless exploitation and war destruction in the modern age: "Threats caused by advanced technology on the scale of nuclear devastation, climate change and species extinction have exposed a fault line between past industrial society and present techno-scientific society. . . . In industrial society, it was possible to evaluate the positives and negatives of technological advancement more or less accurately, but in techno-scientific society it is not."

To cope with this change was highly problematic for nuclear power workers in North America. During the 1950 and 1960s these workers were recruited from conventional power stations fed by coal or oil. Joy Parr (2006) describes reports by early Canadian nuclear operators who at their new workplace could no longer rely on smell or noise when detecting operation faults of their power plant. Oil drops and coal dust that were once the smallest particle in energy production were replaced by neutrons, electrons, and isotopes. These were not only much, much smaller in scale, but in their discrete materiality also an abstract idea that workers could neither see nor imagine. To be safe meant to visualize radiation (no matter if caused by accident or by detonation of a nuclear device, i.e., intentionally or not), and this became a concern of many states in the postwar era. Typically, these visualizations were highly abstract, drawing concentric circles around the point of origin of radiation and declaring that being at a certain distance from that point would ensure safety.[14] Such efforts are undoubtedly inflicted by political concerns where the act of defining safe and hazardous radiation levels—believed to be scientific and accurate—is more often than not arbitrary.[15]

To understand the complex process of visualizing the intangible the following reflections are based on Bruno Latour's (1993) insights on the role of networks in the history of science that link epistemology (the very act of creating knowledge), social sciences (describing the individuals, collectives, and institutions involved in creating knowledge), and semiotics (the effects of meaning constructed in the texts). I intend to show how a paradigmatic epistemological shift in Maoist China enhanced the semiotic approach to small matters in a very particular way. Originally introduced in the 1950s via translation of American and Soviet sources, graphic representations of the atom were a central part of the state propaganda efforts to communicate its nature

[13] How difficult it is to control nuclear power is discussed in Perin 2005, Schoch-Spana 1998, and the many publications on the Fukushima catastrophe. Recent years have also seen the appearance of documentary films dedicated to this topic, such as Hagen 2013 (see description at https://diereisezumsicherstenortdererde.ch/en [accessed 5 January 2018]).

[14] How illusionary this danger assessment actually is can be proven simply by any map describing the spread of nuclear radiation. See an exemplarily map for the case of Fukushima in National Nuclear Security Administration (2013: slide 4).

[15] Research on Chernobyl and Fukushima has shown that declaring areas to be safe or not depends on a variety of social and political factors. See here the numerous publications on both accidents, most prominently Kuchinskaya 2014 and Nancy 2014.

and function to the population. In the 1960s, however, Mao Zedong's epistemology of the infinite described the atom as a tangible and thus controllable matter, eventually resulting in a persisting nuclear optimism.

## 2 Visualizing Radiation

In China, the existence of nuclear radiation was already known since Republican times. In 1924 Xia Chengling 夏承檽 published in the journal *Kexue Zhoubao* 科学周报 (*Science Weekly*) an explanation of the physical phenomenon yet did not provide insights into its dangerous nature. One of the first articles that specifically described neutron and Roentgen radiation as harmful appeared during the second half of 1946 ("Yuanzidan fushexian" 1946). Another article from 1947 identified women—working as nurses and in the food packaging industry—as the occupational group most vulnerable to cancer ("Fushe weixian zuihai nüren" 1947), and starting in 1948 the nuclear testing of the United States on the Bikini Atoll received attention in Chinese media that reported the consequences of radioactive contamination for animals and plants.[16]

These cursory reports—as well as the relatively little information on the nuclear bombing of Hiroshima and Nagasaki available in 1945—only had a minor impact on understanding the nature and danger of radiation. The situation changed fundamentally with the outbreak of the Korean War in 1950. Popular science journals at that time were given the task—next to criticizing warmongering America—to integrate science into larger state projects of building socialist economics, politics, and culture while demystifying the danger of the atom.[17]

In most cases, *kepu* periodicals explained the atom to their readers in a vivid and accessible fashion. Producing a large number of iconic images, they describe the atom as the smallest constituent unit of ordinary matter with the properties of a chemical element. Each atom is composed of a nucleus and one or more electrons bound to the nucleus. The almost perfectly spherical nucleus is made of one or more protons and typically a similar number of neutrons (see Fig. 1). These idealized depictions of the atom are undoubtedly neither images of true reality nor true representations (the impossibility of such endeavor is shown by Heisenberg's uncertainty principle). The rapidly growing findings in nuclear physics research made it increasingly difficult to describe physical reality, especially after the belief of the atom being the smallest material unit (as in the sense of the Greek word ἄτομον, "uncuttable") had been shattered. When the serial article "Yuanzi juren" 原子巨人 ("The Atomic Giant") presented to its readers the 1896 breakthrough of the French scientist Antoine Henri Becquerel that radioactivity caused the phosphorescence of uranium salts, it reinforced the insight that atoms were not the smallest unit of physical matter after all.[18]

16 See, for instance, "Meiguo zai Bijini shiyan" (1948), an article comparing cotton plants before and after exposure to nuclear radiation.

17 On criticizing warmongering America, see the Chinese report "Bijini shijian" (1959) on the first US test of a dry fuel hydrogen bomb (code name Castle Bravo), detonated on 1 March 1954 at Bikini Atoll. Similar critiques supporting the Japanese protest were published: Hou (1955) and Yuwen (1955).

18 "Yuanzi juren," the serial article on the atom in *Knowledge Is Power*, lauded Becquerel's discovery as the beginning of an unlimited energy supply for a world that was striving toward a high-technological modernity,

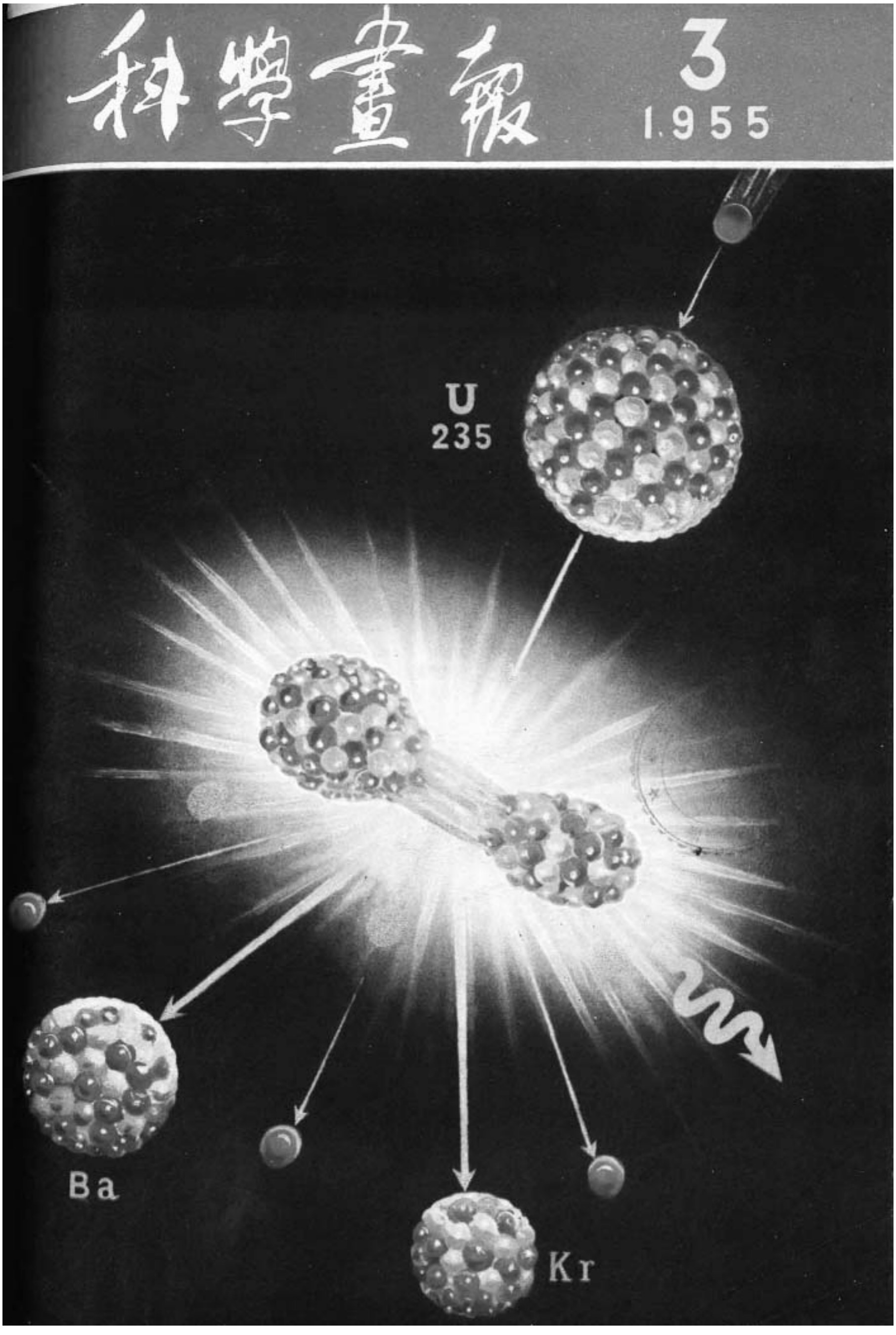



**Fig. 1** Title page of *Kexue Huabao* 科学画报 (*Science Pictorial*), March 1955

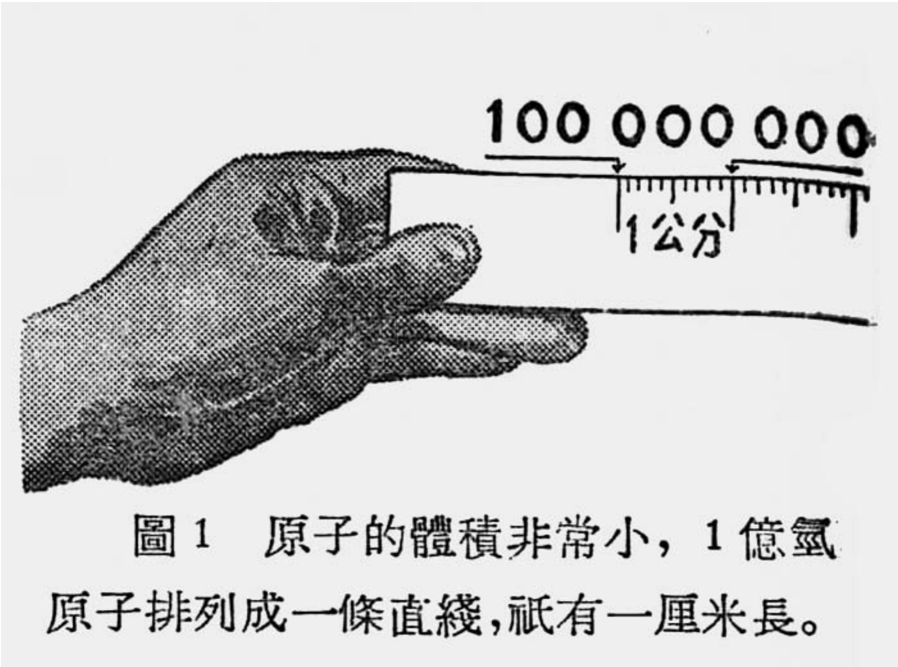



**Fig. 2** Describing the size of atoms, *Kexue Huabao*, March 1955

It is for this reason that science journals of the 1950s and early 1960s relied on metaphors of scale in their semiotic approach to the atom. Instead of simply stating the typical size of one ordinary atom as being around 100 picometers (a ten-billionth of a meter, in the short scale), science journals preferred metaphorical approximations, telling the spectator that 100 million hydrogen atoms put in one line would amount to a length of 1 centimeter (see Fig. 2). In a similar fashion, the size of the nucleus was defined as a ten-thousandth part of the whole atom, or in other words, if the nucleus equaled a cherry, then the whole atom would have the size of a skyscraper of more than 200 meters. Another kind of comparison was if the nucleus had the size of a walnut, then the whole atom would equal a celestial body of 3 kilometers in diameter.[19] These equations give an impression of the size of the atom and the size relations within an atom, yet they are only inadequate approximations. Atoms are objects so small that they can be imagined only in terms of comparison that fall back on quantitative metaphors, or metaphors of scale.[20]

where huge harvests are possible, poverty is eliminated, and the conquest of outer space is no longer unthinkable. The introduction to this text reads that the atom is a giant because it possesses virtually unlimited power despite its extremely small size.

[19] See "Fajue yuanzi de qianneng" (1955). An analog metaphor is used with regard to the weight of electrons. See the picture in "Yuanzi juren." *Zhishi Jiushi Liliang* (1962) 2: 22.

[20] I owe the idea of such metaphor to Mecke 2015. Klaus Mecke has shown that any physical unit in measuring quantities can function properly only if the exactitude of numbers does not leave aside its narrative construction. For instance, electrical resistance is often understood as the property of an electrical component, yet in fact it is a quantitative metaphor defined by the relation of volt and ampere.

In the *kepu* materials, the invisibility of the atom, radiation, and nuclear fission caused the semiotic portrayal of nuclear phenomena to rely on particular figures of speech (see Fig. 3). Understanding complex physical phenomena by rhetorical figures is not extraordinary if we think of “energy,” “black holes,” or “warp drive.” Famous cases where metaphors are used are Albert Einstein’s elevator, August Kekulé’s snake, and Niels Bohr’s model of the atom as a solar system. However, these approaches failed to turn phenomena of the nuclear world into tangible entities. The atom evaded human control because its metaphors were simple metaphors that, contrary to absolute metaphors such as liberty, truth, or history, reduced phenomenological complexity instead of describing objective reality.[21]

While metaphors—being characteristic of popular science language in both the United States and China—were part and parcel of the efforts to make nuclear power a humble servant of humanity, the question remains how this optimism could be sustained when the scary side of the atom emerged, namely, radioactive contamination resulting from a nuclear attack. In the case of the United States, the Cuban Missile Crisis in 1962 caused a nationwide nuclear scare in defiance of the duck-and-cover propaganda.[22] The fear of an atomic attack by US imperialism motivated both the military and the central government in China to invest heavily in the development of an atomic bomb (Lewis and Xue 1988; Feigenbaum 2003), despite the well-known position of Mao Zedong that the bomb was nothing more than a paper tiger. The remainder of this article argues that while this comparison—first reported in an August 1946 interview with the American journalist Anna Louise Strong—has long been considered an important part of Chinese propaganda for reducing the fear of an atomic attack, its contribution to coping with the invisible threat is less significant than a later epistemological turn.[23]

## 3 The Danger of Atomic Bombs

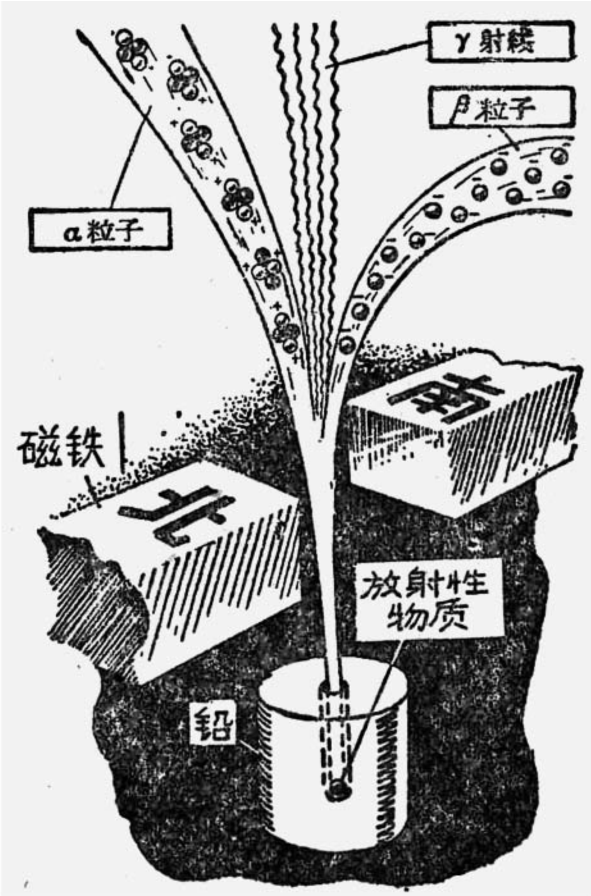
At the time of the Korean War many communist states in Europe and East Asia were discussing the risk of an American nuclear attack on the peninsula (Weart 2012: 60–69), despite President Truman’s assurances in late 1950 that due to its apocalyptic destruction potential he was far from ready to use the bomb in actual warfare. In China, the *Kexue puji tongxun* considered the American use of nuclear and bacteriological weapons an imminent threat and thus engaged actively in demystifying the bomb.[24] Similar to the introduction of the photograph in nineteenth century when people believed that cameras were constructed by making use of children’s eyeballs, today’s task of scientific knowledge was to destroy superstitious beliefs related to the atomic

[21] According to the philosopher Hans Blumenberg (1920–96), an absolute metaphor is a metaphor that is independent of its original context in which it served to illustrate something (Blumenberg 1997). Such metaphors can first and foremost be found in the context of highly abstract concepts that cannot be sensed directly, such as those mentioned here. Metaphors in natural sciences, however, are a different story.

[22] On the nuclear scare in the United States and Western Europe, see Weart 2012.

[23] The paper tiger as an important part of Chinese propaganda is implied in Zhonghua quanguo kexue jishu puji xiehui xuanchuanbu 1950. See here also the exemplarily *Fangyuanzi fanghuaxue fangxijun tietu* 1971. I thank Stefan Landsberger for providing me with detailed scans of this poster series.

[24] On the difficulty of proving the actual use of bacteriological weapons in the Korean War, see Endicott 1979 and Endicott and Hagerman 1999.



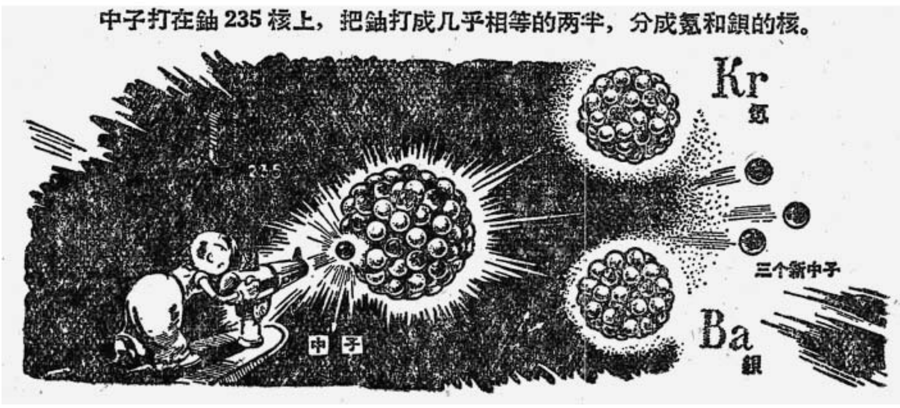




**Fig. 3** “Yuanzi juren” (“The Atomic Giant”), in *Zhishi Jiushi Liliang* 知识就是力量 (*Knowledge Is Power*), January and April 1962


**Fig. 4** “Yuanzidan shi shenme?” 原子弹是什么? (“What Is an Atomic Bomb?”)

bomb, the newsletter argued.[25] It was in this spirit that its November 1950 issue published two color slide shows titled “Yuanzidan shi shenme?” 原子弹是什么? (“What Is an Atomic Bomb?”; Fig. 4) and “Yuanzidan bu kepa” 原子弹不可怕 (“The Atomic Bomb Is Not to Be Feared”; Fig. 5).[26]

During the 1950s and the 1960s slide shows were a central element in visualizing new knowledge. Printed as inserts in journals these pictures were to be scratched on glass slides and then shown on villages squares, which was in that time also a popular form of entertainment.[27] The slides describe how atomic bombs are produced from uranium, what nuclear fission is, and that, considering these bombs are made of physical matter and not any mysterious stuff, one does not need to fear it, especially because a nuclear bomb cannot be used on the battle field (it would also harm one’s own soldiers; see slide 6 in Fig. 5).[28] It is thus nothing more than an idle threat used by the Americans to achieve global hegemony (see slides 8 and 9 in Fig. 5).[29]

[25] See Wen 1950. A text with a similar intention was the 1964 *Pochu mixin wenda* (Q&A on Dispelling Superstition). Intended as a handbook for low-level cadres on the countryside and young people, it lists questions that are answered in terms of class struggle (“Is there heaven and hell?,” “Are good luck and bad luck of man decided by fate?,” or “How does a fortune-teller deceive the people?”). For exhibitions condemning superstition see “Looking Back” (1996).

[26] “Yuanzidan bu kepa” (1950); “Yuanzidan shi shenme?” (1950).

[27] See “Jieshao tu dianying” (1950) and “Huandeng shi kexue puji gongzuo de yige youxiao gongju” (1950). A very good introduction to the role of slide shows and cinema offers in Johnson 2011 and 2015.

[28] This critique addressed the rumors spread by the Yiguandao sect from 1950 to 1954, claiming that peasants had to provide human testicles (蛋 *dan*) to the Soviet Union so that the big brother could provide China with atomic bombs (原子彈 *yuanzidan*). For a detailed analysis of these rumors, see the study of Li 2011.

[29] The 1951 official US government booklet *Survival under Atomic Attack* released by the Executive Office of the President, and the Civil Defense Office likewise underestimated the danger of an atomic attack. Its four core truths that had to be memorized were (1) atomic weapons will not destroy the earth, (2) doubling bomb


**Fig. 5** "Yuanzidan bu kepa" 原子弹不可怕 ("The Atomic Bomb Is Not to Be Feared")

The growing global geopolitical tensions caused by the proxy war in Korea, however, soon raised concerns in the Communist Party leadership and encouraged a nationwide activity to propagate knowledge on protection against possible fallout and shock waves of a nuclear bomb. In 1954 China joined the rising global anti–nuclear weapons movement when fear about atomic and hydrogen bomb testing reached the public in the wake of the extensive testing in the Pacific, during which Castle Bravo—the first test of a deployable thermonuclear weapon—caused a massive nuclear fallout that also affected civilians, among them the crew of the Japanese fish trawler *Daigo Fukuryū Maru* 第五福竜丸. This event brought forth the first substantial news coverage on nuclear testing not only in China (such as in the *People's Daily* in mid-1954) but also in a number of publications that relativized the essential danger.

For instance, the booklet *Yuanzineng tongsu jianghua* 原子能通俗讲话, or *Colloquial Speeches on Atomic Power* (Yuanzineng tongsu jiangzuo zuzhi weiyuanhui 1955), argues confidently that while atomic fallout shelters and underground cities planned by the United States would only show that American imperialism was prone to make actual use of the atomic bomb in its fight for hegemony, it would not cause an Armageddon, despite the fact that China had only small and limited measures of defense. In fact, scientific knowledge on the bomb showed that the actual killing zone of a nuclear attack was about 1.5 kilometers from the center of explosion, and by no means unlimited.[30] In addition, proper means of protection could largely reduce the actual impact. The effect of an attack is thus much smaller than one thinks, as was shown with the nuclear explosions in 1945, and the publication claimed: when the United States attacked Hiroshima and Nagasaki, it was not the bomb that wiped out the military power of Japan but the Soviet entry in the war (Yuanzineng tongsu jiangzuo zuzhi weiyuanhui 1955: 31–33, 36).

Slightly less optimistic was an article in the 1957 issue of *Kexue huabao*, arguing that according to experiences in medical sciences radiation can cause a large number of

power does not double destruction, (3) radioactivity is not the bomb's greatest threat, and (4) radiation sickness is not always fatal (Department of Civil Defense 1951).

[30] Xu Yu reports in his 1952 popular science book on the atomic bomb that protection is possible, contrary to the claim of the United States. Their warning against an Armageddon is in his eyes nothing less than the effort to restore its prime position after the Soviet Union had developed its own bombs. In addition, the fact that the use of atomic bombs makes sense only in densely populated areas advantages both the Soviet Union and China: to cover the whole territory of both states would require more bombs than actually possessed by the United States.

dangerous ailments, ranging from infertility to cancer and leukemia.[31] This judgment is in accordance with the overall intention of the pictured article, namely, to call for an end to all bomb testing: the author feared the extinction of humankind should further testing (and possibly military use) occur. The danger was conceived as highly problematic because radioactive fallout does not have any taste, color, or other characteristics and thus could not easily be detected.[32]

Such worries were however exceptional. The majority of publication titles of that era—such as *Yuanzidan de xingneng he fangyu* 原子弹的性能和防御 (*The Function of the Nuclear Bomb and Protection against It*, 1952), *Yuanzi wuqi de weixie shi keyi xiaochu de* 原子武器的威脅是可以消除的 (*We Can Eliminate the Danger of Nuclear Weapons*, 1956), and *Yuanzineng fushe yuanli he fangbifa* (*baokuo fangyu yuanzidan*) 原子能辐射原理和防避法 (包括防御原子弹) (*The Principles of Nuclear Radiation and Ways of Protection* [*Including Protection against Nuclear Bombs*], 1956)—continued to spread an unshaken optimism, not unlike Mao Zedong in his 1955 speech "The Chinese People Cannot Be Cowed by the Atom Bomb" (*Selected Works of Mao Tse-tung* 1977, 5:152–53). The general assumption in these writings was that protection was possible if only the nature of radiation was understood properly. The confidence on the Chinese side did not differ much from that in the United States, where the duck-and-cover principle was taught in educational films, claiming that even thin cloth or newspaper can provide protection. In fact, the booklet *Yuanzi wuqi jiqi fanghu* 原子武器及其防护 (*Nuclear Weapons and the Protection against Them*; Junshi zhishi congshu 1958), part of a series dedicated to the spread of military knowledge, recommended similar behavioral patterns in the case of a nuclear attack.[33]

It would, however, be too easy to interpret these behavior recommendations—both in the US and in China—to be simple propaganda, for it would imply that both political regimes functioned similarly and that the attitudes toward the nuclear danger did not differ greatly. I show in the remaining part of this article how dialectical materialism in natural sciences provided in China a sophisticated way to explain the invisible not only to the expert but also to the layperson. Understanding the smallest matter scientifically not only was an urge of an era when geopolitical and military conflicts were looming large but also could at the same time potentially contribute to a growing confidence in controlling and managing the invisible threat of nuclear radiation.

## 4 Coping with the Invisible Threat by the Maoist Epistemology of the Infinite

As described above, the discovery of radioactivity had proven that the world of small matter was infinite. This insight is reflected in the Maoist understanding of knowledge production according to which man has to delve into an incessant process of making observations and testing them again and again, so to approach objective reality in a dialectical fashion. It is due to the infinite complexity of natural phenomena that man

[31] For a list and description of diseases caused by nuclear radiation, see Huang 1957. This article supports the appeal of the March 1957 meeting of the World Peace Council in Berlin to end hydrogen bomb testing.

[32] See "Zibenzhuyi guojia zhong de yuanzidan wuqi" (1957), a translated article originally appearing in the Soviet journal *Military Knowledge* (Военные знания).

[33] See the short summary by Forster 2017.

can only successively and gradually gain knowledge, as emphasized in Mao Zedong's philosophical texts *On Practice* (1937) and *Where Do Correct Ideas Come From?* (1963), in which he defines science as accumulated knowledge derived from centuries-long experience.[34] In his *On Practice,* he argues for a sense of historical materialism that strengthened the belief in teleological progress and rejects any belief in metaphysics and superstition. Empirical facts ensure that the world was knowledgeable. With neither theoretical knowledge existing a priori nor theories being formulated first and proven later, it is obvious for Mao that it would be ridiculous to claim that a scholar knows the world's affairs without stepping out of his study room:

> Even though this saying can be valid in the present age of developed technology, the people with real personal knowledge are those engaged in practice the wide world over. And it is only when these people have come to "know" through their practice and when their knowledge has reached him through writing and technical media that the "scholar" can indirectly "know all the wide world's affairs." If you want to know a certain thing or a certain class of things directly, you must personally participate in the practical struggle to change reality, to change that thing or class of things, for only thus can you come into contact with them as phenomena; only through personal participation in the practical struggle to change reality can you uncover the essence of that thing or class of things and comprehend them. (*Selected Works of Mao Tse-tung* 1977, 1:299–300)

For Mao, rational knowledge cannot exist independently or be derived solely from reason. It depends on perceptual knowledge based on a materialist understanding of the world, and anyone who thinks differently commits the mistake of idealism. He points out that "the rational is reliable precisely because it has its source in sense perceptions, otherwise it would be like water without a source, a tree without roots, subjective, self-engendered and unreliable" (*Selected Works of Mao Tse-tung* 1977, 1:302–3).

The challenge was now to apply this view to nuclear physics, that is to reconcile Marxist natural dialectics with intangible phenomena. To rely on measuring equipment such as Geiger counters was certainly one way of enhancing sensual perception to understand radiation, but encountered two problems: to understand how a Geiger counter works while avoiding the shortcomings as witnessed in the case of the

[34] The influential text "Ren de zhengque sixiang shi cong nali laide?" ("Where do correct ideas come from?") was part of the *Draft Decision of the Central Committee of the Chinese Communist Party on Certain Problems in Our Present Rural Work* (1963), where Mao points out that correct ideas stem from the struggle for production, the class struggle, and the scientific experiment, repeating again the circular relation between perceptual and rational knowledge: matter influences consciousness, and consciousness reflects back again on matter. This conceptualization can also be found in his text *On Practice*: "Discover the truth through practice, and again through practice verify and develop the truth. Start from perceptual knowledge and actively develop it into rational knowledge; then start from rational knowledge and actively guide revolutionary practice to change both the subjective and the objective world. Practice, knowledge, again practice, and again knowledge. This form repeats itself in endless cycles, and with each cycle the content of practice and knowledge rises to a higher level. Such is the whole of the dialectical-materialist theory of knowledge, and such is the dialectical-materialist theory of the unity of knowing and doing" (*Selected Works of Mao Tse-tung* 1977, 1:308). The logic of class struggle indeed dictated that scientific knowledge was ideally derived from worker's and peasant's practical experiences, such as in the case of Chinese veterinary medicine, half-mechanization and improvement of agricultural tools, and the technological innovations made by workers, as shown in Matten and Kunze (2017).

microscope, and to provide Geiger counters for everyone who runs a risk of being exposed to radiation. The access to counters (as well as protection measures) was during the Maoist period (primarily due to material constraints) largely restricted to those working in the nuclear industry, and in case of an attack large parts of the populations would remain unaware.[35] The lack of measuring equipment and the complicated nature of nuclear radiation therefore became a challenge to Maoist knowledge theory. If perceptual knowledge no longer evolved into rational knowledge, the epistemology of knowledge could seemingly no longer move in dialectical cycles, nor could science continue to be exclusively socially centered.

In other words, there emerged a considerable knowledge gap between those social groups that were according to the Maoist epistemology of (scientific) knowledge considered to play the primary role of producing knowledge—these were workers and peasants—and the highly abstract scientific knowledge of nuclear physicists. Because practical experience could not be applied as an epistemological principle for understanding and grasping the invisible (something that at least in principle had still been possible with the microscope), knowledge production in nuclear physics—in efforts to use it both for civil and military aims—happened in closed institutions such as the Institute of Physics at the Chinese Academy of Sciences (Zhongguo kexueyuan wuli yanjiusuo 中国科学院物理研究所) and the China Academy of Engineering Physics (Zhongguo gongcheng wuli yanjiuyuan 中国工程物理研究院). This institutional setting was unique in the case of nuclear research (Lewis and Xue 1988; Feigenbaum 2003). It not only created a tension between mass science and theoretical science but also, to some degree, rendered Mao's *On Practice* irrelevant.[36]

From a strictly mass science perspective, this tension had to be resolved. The way to do so was to combine the unlimited potential of the atom to the nature of matter itself. During the 1960s the question whether the division of matter was finite or infinite emerged when Mao Zedong—in the wake of the Sino-Soviet split 1961—formulated a distinct Chinese theory of science. According to him, matter was infinitely divisible (*wuzhi de wuxian kefenxing* 物质的无限可分性) (see also Gong Yuzhi 1965). This, argues Cheng Yinghong, stimulated Chinese physicists to explore the microworld: "Maoist cosmological discourse held that within an infinite time/space continuum, everything in the universe incessantly develops contradictions from within and constantly engages in dialectical transformations between oppositions. Mao himself and Maoist ideologists drew deeply on this thesis when they responded to the scientific findings and theories that had cosmological implications, whether matter is divisible or the universe has a limit in particular" (Cheng 2006: 109).[37]

[35] China's paucity of Geiger counters was similar to the situation in other countries during and after the Cold War. A widespread use of Geiger counters by private individuals actually occurred only recently during the Fukushima crisis when the local population expressed a certain mistrust toward official radiation measurements, preferring to acquire counters for personal use and publishing their measurements online. See Prosser 2016. On the fascination of Mao Zedong and the Politburo when being shown a Geiger counter in 1955, see Lewis and Xue 1988: 38.

[36] A point also taken up by Knorr Cetina 1999, who argues that, when comparing high-energy physics and molecular biology, research in the former discipline often focuses on analyzing its experiments rather than the objects of it, while the latter emphasizes the need of empirical contact. Thus, the epistemic cultures on biology and physics differ greatly.

[37] See the discussion in Cheng 2006. The following part has profited substantially from Cheng's article, for which I express gratitude.

Similar to the well-known saying by Zhuangzi, "Take a foot long stick and remove half everyday. In ten thousand years it will not run out" (一尺之捶日取其半萬世不竭), the Maoist discourse on science held that there is no end in scientific research.[38] Having an end would constitute an end to science itself where the last knowable thing can only be metaphysically founded. To claim that there were elementary particles (*jiben lizi* 基本粒子) that are no longer divisible was a metaphysical belief that contravened the very principles of historical materialism, as argued Gong Yuzhi 龚育之 (1929–2007), the famous dialectical materialist of the post-1949 era. With reference to Zhuangzi's quote he warns not to reject the universal epistemological principle of "dividing one into two" (*yi fen wei er* 一分为二).[39] Recalling Mao's talk at a meeting in Beidaihe on 18 August 1964, where the chairman commented on the nature of matter two months before China succeeded in its first test of a nuclear weapon on 16 October 1964, Gong claims that

> If there is an end, there is no science. The world is infinite. Time and space are infinite. In space, both micro and macro are infinite. Matter is infinitely divisible, therefore scientists have job to do forever, even after one million years. I have heard some discussions and read some articles [on the subject]. I very much appreciate Sakata's article in *Bulletin of the Studies of Dialectical Materialism*. I've never read articles like that. He is a dialectical materialist and cited Lenin's words.[40]

Such was the conceptualization of science that tried to provide an epistemological framework so that the invisible was no longer a scary matter, because even the smallest elementary particle could in the end be fully comprehended. Yet, the persisting invisibility of particles and radiation made it necessary to continue to use metaphors such as Zhuangzi's stick that were justified by couching them in historical materialism.

In the end, nuclear knowledge production—contrary to technological knowledge that in the Maoist vision of an ideal society resulted from the experience of labor and not theoretical reflections—moved from the lower to upper levels in society. Only the educated expert with a sufficient theoretical knowledge in natural sciences was able to apply this knowledge to daily practice and to popularize it (see Stehr and Grundmann 2010). Seen from this perspective, knowledge on nuclear physics appeared to circulate in two different, separated discourses. While iconic metaphors—helpful means to describe analogies of scale and the nature of radiation—were used primarily in publications dedicated to science popularization (similar to American and Western European visual representations of nuclear power such as in the Disney movie *Our Friend*

[38] Legge 1962: 230 (Zhuangzi, *Zapian*, *Tianxia* 莊子-雜篇-天下).

[39] See his contribution in the journal *Red Flag* (*Hongqi* 红旗), dating from August 1965. The quote of Zhuangzi is reproduced here: Gong 1965: 32.

[40] Gong 1986: 102–3; here taken from Cheng 2006: 115. One year later Sakata published his view on elementary particles as a "mistaken concept" in *Red Flag* (*Hongqi*), arguing that matter cannot be separated into elementary and indivisible units, see Sakata 1965. On the views on the science philosophy of Sakata, see also the translation of eighteen of his essays (Sakata 1987). The translation's preface is written by Sakata's wife, who also had close connections with Chinese scholars, among them Guo Moruo and his wife Yu Liqun. *Bulletin of the Studies of Dialectical Materialism* should read here *Bulletin of the Studies of Dialectics of Nature*.

*the Atom*), cosmological-philosophical arguments guided the discussions in more theoretical publications such as the *Red Flag* and the *Bulletin of the Studies of Dialectics of Nature*, both of which applied dialectical materialism to the invisible world. These discourses were, however, not isolated from each other. Rather, they shared a knowledge epistemology that differed decisively from the one in the United States and Europe, thereby explaining why in the long run attitudes toward nuclear power also differed decisively in the East and West. In the United States and Western Europe, the search for the Higgs boson started in the 1960s and has long troubled nuclear physicists where to go once the God particle had been verified. In the Maoist case, matter was believed to be infinitely divisible, making it possible to gain a full understanding of the cosmos. Claiming to be able to control scary radiation was thus not simply the result of the omnipresent voluntarism in the revolutionary era (in other words, a success of the propaganda machinery), but due to the firm belief in the infiniteness of dialectics also epistemologically grounded. This move allowed imagining the possibility of endless progress in scientific research and in that sense handling even those particles that defied human control by their very discrete nature.

## 5 Epilogue

By successfully adapting historical materialism to the realm of the intangible, Maoist knowledge epistemology eventually contributed to the firm conviction that nuclear radiation can be controlled and subjected to human will. It differed significantly from the overtly naive optimism that had been present in both Disney's film on the atomic genie and the 1950s slide shows on the atomic bomb. During the 1980s science dissemination materials produced by the state, such as the 1981 booklet titled *Yuanzi daguanyuan* 原子大观园 (*A Grand View of the Atom*), still maintained the idea that complete protection against nuclear attacks was realistic, given that one had the correct way of thinking and access to sufficient protective measures in the material sense (Wang 1981), yet without reference to Mao Zedong's insights of the mid-1960s. Though historical materialism is no longer the generally accepted foundation of knowledge production in contemporary China, this has in recent years not stopped the nuclear energy sector to justify its ambitious development plans by the belief they are able to generate continuous, never-ending progress in nuclear technology. Nuclear optimism has become a central part of the official modernization discourse in contemporary China to such an extent that even the Fukushima nuclear disaster did not have any major impact.[41] It thus does not come as a surprise that just one day after the catastrophe Zhang Lijun 张力军, the vice-minister of the Ministry of Environmental Protection, claimed in an interview to the *People's Daily* that nuclear energy in China was safe (Hou 2011). Among the Chinese population, however, such optimism seems to have perished: instead of simply believing governmental reassurances, worried people bought large amounts of iodized salt, assuming it was an effective measure for thyroid

[41] See here the Middle and Long Term Plan for the Development of Nuclear Energy 2011–20 (*Hedian zhongchangqi fazhan guihua* 2011-2010 *nian* 核电中长期发展规划 2011–2020年) drafted and ratified in late March 2011, that is, after the Fukushima catastrophe.

protection.[42] In the end, the demise of Maoist knowledge theory—in particular its mass line and the emphasis on social practice—created in the postrevolutionary era a considerable gap between the state and people, thereby not only destroying the chance of a shared knowledge base, but also rendering the invisible fearsome (again).

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[42] This phenomenon was explained by the *Renmin Ribao* as a result of insufficient science dissemination; see Miao Wenxin 2011.

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