



## 温南·洛 (Wynand Louw)

国际计量委员会 (CIPM) 主席

温南·洛博士 (南非)，1995年获物理学博士学位，1998年加入南非国家计量院 (NMISA)，2002年任院长。2013年起担任国际计量委员会 (CIPM) 委员，2014年担任CIPM电离辐射咨询委员会 (CCRI) 主席，2018年当选CIPM主席，2022年成功连任。

2023年11月1日至3日，CIPM主席温南博士出席量子力学与测量关系座谈会期间，接受了《计测技术》的专访。就量子精密测量的最新进展、国际计量委员会 (CIPM)、南非国家计量院 (NMISA) 以及非洲计量合作组织 (ARIMETS) 与中国计量合作的前景以及新计量标准的发展等方面发表意见，并给出中国在这一方向发展上的建议及本次受邀参加“量子力学与计量”国际合作项目国际专家委员会主席后对未来项目开展的建议。主编韩冰介绍了期刊的创刊历史，盛意邀请温南博士作为期刊国际编委指导期刊工作，温南博士肯定了《计测技术》长期坚持专注于计量测试领域的价值，并就如何办好科技期刊发表意见、给与指导，之后为期刊题词：希望《计测技术》能够搭建交流平台、展示技术成果、发挥桥梁作用、推动项目进展。

近些年来，量子精密测量已经成为量子信息科学与技术领域的一个特殊且发展极为快速的技术分支。以量子力学系统为基础来测量各种物理量，从几何量、温度、重力、磁场、电场再到时间和频率，基于量子力学的精密测量技术几乎可以覆盖所有计量领域的科研应用。

国际计量委员会 (CIPM) 主席温南·洛 (Wynand Louw) 2023年11月访问中国各计量机构期间，提出应加强合作，共同推进量子力学与测量项目进展。

## 《Metrology & Measurement Technology》INTERVIEW

Dear Dr. Wynand Louw, nice to meet you! I am the editor in chief of Metrology & Measurement Technology, my name is HAN Bing, and you can also call me Alice. Welcome to China! Welcome to Changcheng Institute of Metrology & Measurement! I'm glad you can accept the interview with "Metrology & Measurement Technology".

The first question:

What is the latest progress in quantum precision metrology internationally? What are the suggestions for China's development in this direction?

Wynand: Yeah, good day and it's really my pleasure to be here. And thank you for the hospitality of the institute. It's really appreciated! Yes, the International Committee for Weights and Measures coordinates the work that is done to

尊敬的 Wynand Louw 博士，很高兴见到您！我是《计测技术》的主编韩冰，您也可以叫我 Alice。欢迎您来中国！欢迎您来北京长城计量测试技术研究所！很高兴您能接受《计测技术》的采访。

国际上，量子精密计量的最新进展如何？对中国在这一方向发展上的建议是什么？

温南：您好，我很高兴来到这里！感谢贵研究所的盛情款待，我诚挚地表示感谢！是的，国际计量委员会 (CIPM) 协调为确保可追溯到

ensure the traceability to the international system of units. Officially, we also established the international system of units and we maintain the system, and we also propose new ways of actually taking traceability for measurement. Now, at the moment, the traceability systems are well set up for classical measurement methods, but we know that the world is moving towards quantum mechanical precision measurement. And basically, with the revised SI, we did the revision in 2018, so it was implemented in 20th, May 2019. And with that revised SI, we really moved into, we started to get ready for quantum metrology as well, because the definition now makes it possible. For example, the kilogram before the revision was defined in terms of the mass of the international prototype of the kilogram held at the headquarters of our organization, the International Bureau of Weights and Measures in Paris. But now the kilogram is defined in terms of the Planck constant, now immediately, you can now realize the kilogram anywhere in the world with a few methods. One is the Kibble Watt balance, other one is Avogadro experiment, the X-ray crystal density experiment or project. And in China, you use a Joule balance to realize the kilogram. So that really makes it possible for us now to define the ways to do quantum metrology. And as the CIPM, we realize this and we are now getting ready to make sure that the systems exist internationally and to set up the standards for quantum metrology because the measurement standards that we have at moments are for the classical measurement methods. And where do I see China go? I am very impressed the last week as I visited many of your institutes and your National Institute of Metrology in Beijing. And I can see that China is really coordinated in the development of quantum metrology in the country. I could see from the seminars that I attended last few days, and I also visited the program for quantum devices at the national institute of metrology. So, you are obviously developing new quantum precision measurement devices. And I think if you also have a very good knowledge of the theory, of the quantum theory, the theory of quantum mechanical devices, so therefore China can do two things. You can participate

国际单位制所做的工作。我们正式建立了国际单位制，并维护着这个体系，还提出了新的方法来形成可追溯性。目前，经典测量方法的溯源体系已建立好，但我们知道，世界正在朝着量子力学精密测量的方向发展。我们在2018年进行了SI修订，并于2019年5月20日实施。随着SI的修订，现在的定义使量子计量成为可能，我们真的进入、也开始为量子计量做好准备，例如，修订前的“千克”是根据位于巴黎的国际计量局总部保存的国际千克原型的质量来定义的。但现在“千克”是根据普朗克常数定义的，当前你可以通过几种方法在世界任何地方实现“千克”。使用基布尔天平（以前称瓦特天平），阿伏伽德罗实验或通过X射线晶体密度实验研究。在中国，用焦耳天平来实现“千克”。因此，这确实使得我们现在定义量子计量的方法成为可能。作为国际计量委员会（CIPM），我们意识到了这一点，我们现在正准备确保这些体系在国际上存在，并逐步建立量子计量的标准，因为我们目前的测量标准是针对经典测量方法的。中国将走向何方呢？上周，我参观了你们的许多研究所和位于北京的中国计量科学研究院，给我留下了深刻的印象。我可以看到，中国在量子计量的发展方面确实是步调一致的，从最近几天参加的研讨会及对中国计量院的量子装置项目的参观中可以看出：你们显然正在开发新的量子精密测量装置。如果你们对理论（量子理论、量子力学器件的理论）也有很好的了解，我认为中国可以做两件事：可以参与并为量子计量理论的根本建立做出贡献；也可以促成量子计量测试设备的加工制造。我看到了中国正在朝着这个方向

and contribute to the research for the fundamentally establishments of the theory for quantum metrology, and you can really contribute to the manufacturing of quantum metrology and quantum measuring devices. And I can see this way that China is going and I think it's excellent. And I think you can and will make great contribution to the international quantum metrology.

The second question:

As the Chairman of the International Expert Committee, What suggestions do you have for the future development of the "Quantum Mechanics and Measurement" international cooperation project?

Wynand: Yes, obviously, you've got a consortium of institutes that are participating in this project. I met three of the institutes, of course, today, I am here at the third one. And I saw the publications that you really did in this field. And I think I probably answered the question already in the sense that I can see that you have the capability to really do the fundamental research and to contribute to the fundamental theory of what we will need to set up a quantum standard because you know to have the quantum measurement devices is one thing, but now you must really setup the standard. And I really invite your institute that are doing quantum metrology or quantum precision measurement, you are starting to go into quantum metrology to really expand that project but to always keep to the fundament part, the theory and to develop that and do the research on that. And then I see that you can really going to contribute to the physical development of the standard. You have got the technology to do that. I can see that you have got the manufacturing technology. So, I am really looking forward to be a part of the project. My job is really to help with the coordination and to help to really make the links to the international quantum metrology community.

The third question:

Could you please talk about the prospects of metrology

发展, 我认为这好极了! 我认为你们能够也必将为国际量子计量做出卓越的贡献!

您作为“量子力学与计量”国际合作项目国际专家委员会主席, 对未来项目的开展有哪些建议?

温南: 是的, 显然你们有一个研究所联盟正在参与这个项目。我和其中的三个研究所都有过接触。今天来到第三个研究所, 看到了你们在这个领域真正做过出版物。我想我可能在某种意义上已经回答了这个问题, 因为我看到你们有能力进行基础研究, 并为我们建立量子标准所需的基础理论做出贡献, 因为你们知道, 拥有量子测量设备只是基本条件, 现在你们必须真正建立标准。我真诚地呼吁你们这些正在进行量子计量或量子精密测量的研究所, 你们已开始进入量子计量领域, 来真正扩展这个项目, 但要始终坚持发展并研究基础部分, 即理论。那么, 我看到你们真的可以为标准的实际发展做出贡献。你们有技术做到这一点, 我看到你们掌握了制造技术。所以, 我真的很期待能成为这个项目的一部分。我的工作实际上是协助与协调, 帮助大家真正与国际量子计量界建立联系。

请谈谈您所在的国际计量委员会(CIPM)、南非国家计量院(NMISA)以及非洲计量合作组织(ARIMETS)与中国计量合作的前景?

温南: 让我们从你们与国际计量委员会的合作开始。我们实际上是由在2018年已经加



cooperation between the International Committee on Metrology (CIPM), National Metrology Institute of South African (NMISA), and the Intra-African Metrology System (ARIMETS) with China?

Wynand: Let's start with your cooperation with the International Committee for Weights and Measures. We were actually led by the member states, the countries that belong to the meter convention in 2018, that was just after the revision. So we realized okay this revision. So, of course, we will have to look at the implementation of the revised SI, like the realization of the kilogram now in a quantum way actually with the Kibble Watt balance, the Planck constant and the X-ray crystal density project. But we then say to ourselves a lot of things because at the moment, the international metrology system is set up in the vertical structures, so we've got 10 consultative committees, but they each work on a specific domain of metrology of measurement. So, we have got a Consultative Committee for Mass and Related Quantities, one for temperature, one for electricity and magnetism, one for chemistry and biology, ionizing radiation, photometry and radiometry, and so on. But you see now that whole consultative committee they coordinate the work only for that. But if you now go to quantum measurement devices, for example Kibble Watt balance that this now the new way that you can realize the kilogram, it is really a quantum way of realizing the kilogram in terms of Planck constant that's part of the quantum of world, and we saw, we immediately realize that these vertical structures will not be able in future to address all the questions that you need to address for things like quantum metrology. So, what we are doing now is we are establishing what we call horizontal forums. And the horizontal forum, the first one that we did was climate and environment, because to study climate and environment, you need many of these, you need mass, you need temperature, you need photometry and radiometry, you even need length. And because the setup like that is difficult now to work together, so now we establish horizontal forums.

入“米制公约”的会员国领导的，那是在刚修订之后。所以我们意识到这次修订是可行的。当然，我们必须考虑修订后的SI的实施情况，就像现在通过基布尔天平、普朗克常数和X射线晶体密度研究项目以量子方式实现千克一样。在那个特定时刻，我们会考虑很多事情。因为目前，国际计量体系建立于纵向的组织结构中，我们10个咨询委员会都在计量的特定领域工作。因此，我们有一个质量和相关量的咨询委员会，一个温度的，一个电学和磁学的，一个化学和生物学的，电离辐射、光度测定和辐射测量，等等。你现在可以看到：整个咨询委员会只为这些方向进行协调工作，但如果你现在使用量子测量设备，例如基布尔天平——一种实现千克的新方法，它实际上是一种用普朗克常数实现千克的量子方法，这是世界量子的一部分，我们立即意识到，这些纵向组织结构未来将无法解决像量子计量等需要解决的所有问题。因此，我们现在正在做的是建立我们所说的横向论坛。横向论坛，我们做的第一个是气候和环境，因为研究气候和环境需要质量、温度、光度和辐射测量、甚至需要长度测量。因为这样的机构设置现在很难合作，所以现在建立了横向论坛；第二个是数字化；我们想第三个将是量子计量。我们将在明年也就是2024年的3月举办一次研讨会，将听取所有国家计量机构和其他参与者的意见，这正是好事。咨询委员会的成员只能来自国家计量机构，比如中国的国家计量科学研究院（NIM），但在横向论坛上，我们邀请所有在该领域具有专业知识的人参与进来，我们希望在这里看到我目前接触的参与这个量子项目的研究机构，现

The second one is digitalization. We think the third one will be quantum metrology. We will have a workshop in March next year, 2024. We will listen to what all the national metrology institutes say and the other role players. And that is now the good thing. The consultative committees, the members can only be from the national metrology institutes, like NIM China, but the horizontal forums we are inviting everyone with expertise in the field to participate, and that is also where we like to see institutes that I meet now that to participate in this project, the quantum project, where you can now be invited to participate in the horizontal forum of quantum metrology. So, I see that is where the big collaboration is going, with the CIPM and country like China. Because now we not only to go to collaborate with NIM China in the vertical structures, but also with all your other expertise we can now invite in these horizontal forums. So that is on the CIPM and China. And I say my home institute, the National Metrology Institute of South Africa, we are now developing a Kibble Watt balance, and the prototype is already working. So we will in the next year, we will realize the kilogram in the quantum way. And obviously China you also have got the Joule balance at NIM and I think there are some of your other institutes that are also now getting involved in the new realizations. And so, I can see that a lot of collaboration directly between the Chinese institutes and NIM and NMISA but also your provincial institutes because we also directly do calibrations and things for industry like your provincial institutes. So we are already collaborating with at least four of your provincial institutes like Chengdu, Xiamen, and so on. So I can only see that is great. When you mentioned what the institute here is doing and how good is in dimension, and we do a lot of dimensional work, and so I can see a lot of things that we can cooperate in. It's good to AFRIMETS, the Inter-Africa Metrology System, we started in 2006, we started the Inter-Africa Metrology System, there are now 48 countries that belongs to this, and we have only 5 institutes in Africa that really do the primary realization of the units, South Africa, Kenya, Egypt, Morocco, Tunisia. The other countries all get

在可以邀请你们参加量子计量的横向论坛。我认为这就是国际计量委员会（CIPM）和中国这样的国家大规模合作的方向。因为现在我们不仅要在纵向结构中与中国 NIM 合作，而且要与我们在横向论坛上邀请到的所有其他专业机构合作，这就是国际计量委员会（CIPM）和中国之间的合作。

谈一下我家乡的研究所,南非国家计量院,我们现在正在开发基布尔天平,其原型已经开始工作,所以我们将明年以量子的方式实现千克。很明显,在中国,中国计量科学研究院已拥有焦耳天平,我想你们其他一些研究机构现在也参与到新定义的实现中。因此,我可以看到,中国的研究所、中国计量科学研究院以及你们的省级研究所与南非国家计量院之间有很多直接的合作,因为我们也直接为行业做校准和其他事情。仅我所见,现在已经在与你们至少四个省市级研究所合作,这是非常棒的!你提到这里的研究所所做的事情,且在某种程度上做得如何好。我们做了很多维度上的工作,所以我们可以看到很多我们可以合作的事情。这对非洲计量体系是好事。我们于 2006 年启动了非洲计量体系,现在有 48 个国家参与,而我们在非洲仅有 5 个机构在开展国际单位的基本实现工作,他们分别设在南非、肯尼亚、埃及、摩洛哥和突尼斯。其他国家都从我们那里获得可溯源性,然后作为二级标准运行,其运行方式与你们的省级机构类似。这种方式让我们作为非洲计量体系与中国合作得确实很好,因为你们的省级机构和非洲区域的官方计量机构工作模式是一样的。因此,我们将可以真切看到区域计量组织非洲计量体系以及中国研究所之

their traceability from us and they operate only as secondary standards, they operate like your provincial institutes. This way is really good for us to collaborate as AFRIMETS with China, because your provincial institutes, they do things the same way as the regional NMIs in the regions in Africa. So we can really see a lot of collaboration that is going to happen between the AFRIMETS organization, the regional metrology organization AFRIMETS and then the Chinese institutes.

The forth question:

On March 20, 2019, after being elected as the Chairman of CIPM, you visited China and received an interview titled "The Opportunities and Challenges of the Development of Metrology and Measurement in the Evolution of the International System of Units". Your philosophy was that every industrial revolution was accompanied by the development of a new measurement standard at that time. So, more than four years have passed, what is the situation now? How do you view this issue now? Do you have any new ideas?

Wynand: Yes, at that time, we spoke about the fourth industrial revolution, and that's really, of course, automation, digitalization and big tech that creates big data, and so on. And it's very interesting that you ask me this question because yesterday I driving, I was thinking in the car, ok, what is the next revolution? And maybe the next revolution is the quantum revolution that we are really taking things to the atomic scale. And of course, that fits in perfectly with what we are talking about the quantum precision measuring instruments and quantum metrology. So perhaps the next revolution is really going to be what and how are we going to develop industries based on really the quantum and the atomic scale. And I think it's going to be extremely interesting in the next few years. And it has already started, it's not that it is going to start, it has started. You can see that can see last week in China what we have been discussing in the CIPM. We know it's happening and

间的大量合作。

2019年3月20日您在当选为国际计量委员会主席后到访中国，并接受主题为《国际单位制演变中计量与测试发展的机遇和挑战》的采访。您当时的理念是每一次工业革命都伴随着一个新的计量标准的发展。那么又过去了四年多，现在的情况如何？您现在如何看待这个问题？有什么新的想法？

温南：是的，当时我们谈到了第四次工业革命，当然是自动化、数字化和大数据等等。你问我这个问题很有趣，因为昨天我开车时在想：好吧，下一次革命是什么？也许下一次革命是量子革命，我们真的把一切带到了原子尺度。当然，这完全符合我们所说的量子精密测量仪器和量子计量学。因此，也许下一场革命将是我们如何发展真正基于量子 and 原子尺度的工业。我认为在接下来的几年里会非常有趣。它已经开始了，并不是将要开始，而是已经开始。上周在中国，你可以看到我们一直讨论什么。我们知道它正在发生，这就是为什么我们要开研讨会，并要建立横向量子计量论坛。所以这就是我的想法，这将是第五次工业革命。





that is why we left to workshop and want to set up horizontal forum for quantum metrology. So that is what I think. This will be the fifth industrial revolution.

The fifth question:

《Metrology & Measurement Technology》 was founded in 1958 and is a long-standing academic journal in the field of measurement and testing in China.

You and your organization should have participated in many journal work directly or indirectly and have rich experience in running journals. What do you think should be done to run a scientific journal well?

Wynand: Yeah, I think the advantage that you have and I can see in the journal is very focused. It focused on the specific field. And what you publish obviously is thing very available for your readers in this field. And we know that China has got a very well organized and very big metrology community. And so that is why I think your journal is excellent. And if I were you, I would actually really stay with that and to always focus on this field because you may decide to also broaden it up for more research and things like quantum metrology or precision measurement, but I would think that it would always be good for you to really keep. There are many scientific research journals, I think this one is very focused. You have your target audience and it is very valuable for your target audience, and I think you are running it extremely well. And maybe one day you can start a new edition to your journal, and really then if you start to publish a lot on the higher level research in quantum precision measurement for example, perhaps do that as a new part of your journal. I really think that can work well.



《计测技术》最早诞生于1958年，在中国，这是一本历史悠久的计量测试类学术期刊。您和您所在的机构应该直接或者间接参与了不少期刊工作，办刊经验丰富。您认为应该如何办好一本科技期刊？

温南：是的，我认为你们的优点是非常专注，我在期刊上可以看到这一点，它侧重于具体领域。很明显，你们所发表的内容对这个领域的读者来说是非常有用的。我们知道，中国有一个组织良好、规模庞大的计量界。这就是为什么我认为你的刊物出色。如果我是你，我真的会坚持这一点，并始终专注于这一领域，因为你可能会决定将其扩大到更多的如量子计量或精密测量这样的研究领域，但我认为，真正坚持下去对你来说总是有好处的。科研期刊有很多，我觉得这一本很有针对性。你有自己的目标受众，这些对你的目标受众来说非常有价值，我认为你们刊物办得非常好。也许有一天你可以为该期刊开一个新的版本，然后如果你开始发表一些例如关于量子精密测量的更高水平的研究，也许可以把它作为你期刊的一个新部分。我真的认为这样做很好。

希望《计测技术》能够  
搭建交流平台  
展示技术成果  
发挥桥梁作用  
推动项目进展

温南·洛  
2023年11月03日  
(采编 / 韩冰)