

前有霍金对人类的忠告，后有“三体”中对近未来的预言畅想，当我们以为自己已经无限接近外星文明的时候，哈佛大学黑洞计划的创始主任、天体物理学家 Avi Loeb 指向他发现的太阳系外来客奥陌陌 (Oumuamua) 向人们展示：科幻即未来的科学。Numéro 与这位饱受争议的科学家展开了一场关于星际与未来的精彩对话。

星际约会

采访 Zac Bayly，插画 秦川

AVI LOEB



想必它们的到来并不只是神奇地碰上了我们开发技术的阶段,对吗？

是的,这只是因为我们现在才有能力探测到它们。在此之前,我们没有。所以,当恩利克·费米(Enrico Fermi)说“其他人在哪里”的时候,他并没有真正的仪器设备，没有望远镜来透过窗户观察。他就坐在客厅里,说:“我没看见我的邻居们。”

（笑）我家的百叶窗是关着的，但我看不到我的邻居。

是的,你最好透过窗户去看,最好用高品质的望远镜来观察你的邻居。就在过去的五年里,我们发现了第一批来自太阳系外的星际物体,前两个又是不同寻常的。第一个是我们谈到的2014年那颗流星,第二个是奥陌陌。这两个物体看起来都是非主体物件,它们是异常值。我想说的是,如果我们初步发现的物体看起来很奇怪，那么也许我们对宇宙邻居的了解还不够。

是的,没错。

让我给你举两个例子。一百年前，人们认为太阳是由与地球相同的物质构成的。后来，一位名叫塞西莉亚·佩恩-加波施金（ Cecilia Payne-Gaposchkin ）的年轻科学家决定在哈佛大学做她的第一篇天文学博士论文，她得出的结论是，实际上，太阳主要是由氢构成的，而不是像地球一样由岩石构成的。而这一观点与当时的普遍信仰正相反，事实上——

这是哪一年？

她的博士论文是在1925年完成的。

噢,所以还不到一百年前。

是的,98、97年前。实际上,她的论文委员会中有一位杰出的天文学家,他的名字叫亨利·诺利斯·罗素(Henri Norris Russell),是普林斯顿大学天文台的主任。他当时说,“这不可能,你得把这句话从你的论文中去掉。”他对她说道。而当时的她只是一个年轻的女性科学家,只能回答道,“好吧,我把它删掉”,否则她就拿不到博士学位了。她把这个结论撤回了,但在那之后的四年间,这位主任收集了自己的数据并进行了分析,四年之后得出了结论,发现原来她是正确的,她是对的。

没错,我记得我读到过这个故事,当时我心想“真是个混蛋”。

是啊,真是个混蛋。然后第二个故事是在1933年,一个三十多岁的天文学家名叫弗里茨·兹威基(Fritz Zwicky),他发现在星系团中发现的大多数物质不可能是我们在太阳系中看到的物质,不可能是构成我们的普通物质。

你指的是暗物质吗？

是的,他是第一个论证宇宙中存在暗物质的人。之后的40年间,他一直被嘲笑,包括在他自己的学校,加州理工学院。这个有关暗物质的观点完全被否定了。他们说:“不,我们知道有什么物质存在,我们在太阳系中能看到它们,除此之外别无其他。”而如今,仅仅过了40年,人们开始认真地看待这件事,当然到现在已经是众所周知了。但我们仍然不知道这种物质是什么。它占宇宙中所有物质的80%,我们却不知道它到底是什么。这是第二个例子。故事的第三部分是我们过去五年中发现的星际物体,其中前两个看起来并不像我们在太阳系中看到的陨石。所以,我说,这样的案例一次又一次地出现:太阳和地球构成的物质不相同;宇宙中的大部分物质都不是我们在太阳系中发现的那些;接着是那些星际物体似乎与我们迄今为止在太阳系中发现的岩石并不相似。我觉得我们应该以开放的心态来迎接惊喜。

是的,没错。考虑到我们星球上有生命,而我们对太阳系以外的宇宙空间知之甚少——我们的一个例子就是太阳系中的一颗行星上有着丰富的生命,这就意味着可能存在许多其他类似的地方,对吗？

是的,所以现在我们知道了一些十年前不知道的东西,那就是,根据开普勒卫星的数据,我们知道在所有类似太阳的恒星——看起来像太阳一样的恒星——中,有百分之几到百分之百的恒星中有一颗地球大小的行星,大致在相同的距离。所以,你基本上是在掷生命骰子,智慧生命的骰子,仅在银河系就有数百亿次,所以即使几率很小——

也仍然可能存在很多,对吗？

是的。鉴于大多数恒星的诞生时间都比我们的太阳早数十亿年,我认为很有可能在我们之前的10亿年前,在另一颗恒星周围的系外行星上,有比爱因斯坦更聪明的科学家,远远比我们更早存在。而那些受益于彼方智慧的文明、技术文明上的生物可能已经发送了探测器,现在已经到达了我們这里。即使他们只使用化学推进剂,他们也可以穿越星际,穿越银河系,来到我们身边。那么,我们是否生活在一个我们身边有来自其他文明的探测器的现实中间呢？这不是一个哲学问题;这是一个我们可以用望远镜来回答的问题,只需要你环顾四周。这就是我一年前建立“伽利略计划”的基本逻辑。

这是我很好奇的一件事——当这实际上是一门科学时,对这些想法的抵制。这不是科幻小说,而是说这些都是可能的,让我们去探索它们吧。
没错。

我很想知道你现在在科学界会遇到什么样的阻力。

嗯,就像你刚才说的,如果你看一下我发给你的威尼斯电影节的文章,在最后他们会问我,关于我们近在咫尺的未来,对于像意大利Side Academy里的年轻学生,你想传递什么信息。而我的信息很简单:过去被认为是科幻小说的东西将来可能会成为科学。这就是我跟他们说的。

就好比假如你在一百年前预测未来会出现手机,你会被认为是个疯子,对吧？

是的,如果你想象一个史前时代的穴居人去到纽约市,看着城市里所有的玩意儿,这个穴居人永远不可能对任何东西进行逆向工程。如果我们遇到比我们先进得多的技术设备,那是最有可能发生的情况。因为我们的现代科学技术只有一个世纪的历史,而这只是地球或太阳年龄的一个微小片段。所以我们很有可能会遇到比我们先进得多的生物。还有另外一种可能,存在一些非常原始的文明,但为了访问他们,我们必须乘坐宇宙飞船,把我们带到那里,这将会花费非常多的时间。那是一项非常乏味的工作。最有可能出现的情况是,我们会先遇到一个前来造访我们的外星文明,而且会有技术差距。它们可能会更先进,我们应该对此保持开放的心态,因为有可能它们所有的设备都是人工智能装备的。我把这称为AI宇航员。它们不会是生物,因为——

生物必须要能够在这种太空旅行中生存下来。

没错。他们无法在漫长的旅途和恶劣的太空条件下生存。所以我的预期是,我们很可能会遇到类似的东西,或者是一些太空垃圾设备,它们已经无法使用了。而且有可能奥陌陌只是从某个航天器或者类似的设备中脱离出来的表层零件。这是有可能的。

根据太阳光的反射探测到的奥陌陌,它有一个足球场那么大——你知道,非常大的东西。

而且像煎饼一样平坦,对吧？

是的,它的特性十分不寻常。根据太阳光的反射来看,它很可能是平的,而且它被某种神秘的力量推离了太阳,没有显示出彗星迹象或者尾巴。2019年,另一颗被命名为“2020 SO”的天体具有同样的特性——它被反射光的力量推离了太阳,却没有彗星迹象或尾巴,结果研究发现那是美国宇航局(NASA)在1966年发射的火箭助推器。

哇,太神奇了。

“2020 SO”也是由夏威夷的同一台望远镜Pan-STARRS发现的。现在我们知道它是人造的,因为我们生产的。但问题是:谁制造了奥陌陌？

确实。

所以这是奥陌陌,但如果我们回看2014年的那颗流星,它是一个西瓜大小的物体,比奥陌陌小了200倍。我们能看到它的唯一原因,尽管它是如此之小,是因为它在地球的大气层中燃烧了起来,并与地球相撞。你可以把地球想象成一个渔网:它在太空中围绕太阳移动,然后时不时地与天体相撞。这颗流星在地球的低层大气中燃烧并解体,但它是一个异常值,因为它比同一类型中的所有其他流星都要坚硬。它的硬度是铁的两倍,这很不寻常。此外,我们计算出它在太阳系外的运动速度比太阳附近95%的星体都要快。因此,它显然是一个非主体物件,有趣的是,它究竟是天然的还是人造的。当它解体时,碎片散落在了巴布亚新几内亚海岸外约100英里处,因此我们正计划开展一次探险行动,去搜寻那里的海底。最有可能的是,我们将找到像尘埃颗粒大小的微型碎片。但也有可能,或许有一些来自主体、来自主要机体的零件残留,如果我们能够找到它们,要是上面有一些按钮的话,那我会很想要按下其中一个。（笑）

（笑）这是费米悖论中我发现的一个有趣的地方（费米悖论阐述的是对地外文明存在性的过高估计与缺少相关证据之间的矛盾，总结为一个问题“但大家都在哪里呢？”），如果这个物体在二三十年前撞落到了海洋中的同一个地点，我们也许根本就不会发现它，对吗？我们是直到近期才有能力去进一步观测到这东西。
没错。关键是直到最近五年，天文学家才发现了星际物体——来自太阳系外的物体。我指的是大物体，而不是尘埃颗粒。

理论物理学家和哈佛大学天文学家Avi Loeb正在执行一项任务，即探索宇宙中存在的奇迹——比如那些生活在地球大气层之外的生物。虽然在太阳系内的其他行星和卫星上寻找生命起源前的分子和微观生命的迹象是一项被广泛接受的科学努力，但对复杂的地外生命和确切的外星文明（过去或现在）的搜索长期以来一直被置于边缘科学和科幻小说中。Loeb认为这种情况不应该再继续下去了。2021年，他就这个话题出版了两本富有远见的书。第一本是《天外来客：地球之外智慧生命的首个迹象》（ Extraterrestrial: The First Sign of Intelligent Life Beyond Earth ），书中热情地论证道，2017年曾穿越太阳系的那个名为“奥陌陌”（ ‘ Oumuamua ）的星际物体所带有的奇特属性表明它既不是彗星，也不是流星，而是某个外星文明的产物。第二本是《宇宙中的生命：从生物特征到技术特征》（ Life In The Cosmos: From Biosignatures To Technosignatures ），它全面分析了在宇宙中发现生命的多种可能性——这是一本新兴天体生物学领域的教科书。从2011年到2020年，Loeb是哈佛大学天文学系任职时间最长的系主任，如今他是“伽利略计划”（ Galileo Project ）的负责人。该项目旨在“将对地外科技文明（ ETCs ）的技术特征的搜索工作，从偶然的或轶事的观察与传说纳入到透明、有效和系统化的科学研究主流中”。多么令人兴奋啊！

Numéro:我想跟你讨论的一件事是关于你对科幻小说的看法。

Avi Loeb:嗯,提到科幻小说……明天威尼斯电影节就要开幕了,他们告诉我将有一场“与奥陌陌相会”的活动——那个来自星际空间的物体,我曾经为此写过一本书——以此来纪念这本书的意大利语译本。他们有23个电影项目,都是由意大利Side Academy一年级的学生提交的,灵感全都来自于我的书。

太棒了！《天外来客》那本书问世后，还有哪些人向你伸出了橄榄枝？

自从这本书出版后,在一年半的时间里,我接受了大约1700个采访……还有大概50位——五十！——电影制作人和纪录片导演联系过我,表示有兴趣拍一部关于它的纪录片或电影,这就能让你感受到有多少人对此感兴趣。当然,除此之外,我刚刚写完了另一本续集,它将在2023年6月出版。

我能问一下新书的主题是关于什么的吗？

新书谈论的是关于人类的未来及其与外星智慧生命的关系。最近有很多人对于另一个天体“CNEOS 2014-01-08”感兴趣,我在奥陌陌被报道后的两年之后发现了它的星际来源。事实证明,这颗流星才是我们太阳系中探测到的第一个星际物体,因为它是在2014年1月8日(撞击地球)被探测到的,而奥陌陌是在2017年10月19日。所以说,奥陌陌的发现与首个星际物体到来之间相差了将近四年。我们是



除此之外,在你的一篇题为“星际约会”的Medium文章中,你提到了一种可能性,即外星科技智能文明可能非常先进,以至于在我们相遇之后,我们可能会被“幽灵化”。这对我来说意味着他们可以去到宇宙中的任何地方,他们已经在许多地方看到过生命,所以我们只是平平无奇。

没错。这就好比人行道上的蚂蚁看到骑着自行车路过的人。骑自行车的人不会在意某个特定的蚂蚁群。我们入局宇宙游戏的时间太晚了。整个宇宙已经存在了大约138亿年。我们是最后才出现的。

你是否认为,如果存在另一个物种或文明如此先进,它们有可能类似于我们在地球上研究较低智的生命体,如头足类动物、鲸目动物或鸚科动物之类的,就像在表现某种智慧迹象。它们跟我们不一样,但是——

你知道吗,我不确定我们人类有那么聪明。我去太空中寻找智慧生命的原因之一就在于我在地球上很少看到智慧的存在。

(笑)对。

我们人类不聪明的一个迹象就是,有一架“新视野”号(New Horizons)飞船,由美国宇航局派去研究冥王星(Pluto),他们想要纪念发现冥王星的科学家克莱德·汤博(Clyde Tombaugh),于是在“新视野”号飞船上安装了一个盛有30克汤博骨灰的盒子。现在,想象一下假如外星人发现这个盒子,他们会说:“这没有道理啊,这些人类真的很奇怪,他们想要纪念一个人,却烧毁了他的DNA,摧毁了他的遗传信息。”你知道,这些骨灰就跟香烟灰一样的。

我们真的这么做了吗?

我们真的做了! 一个叫NASA的科学组织做的。

天哪。

这个“新视野”号项目是由一个我认识的首席研究员负责的,他也是伽利略项目的成员,他的名字叫艾伦·斯特恩(Alan Stern)。我找到他,我说:“艾伦,你们为什么要这样做? 这说不通啊,你们应该发送一份汤博DNA电子记录,里面会有一些内容,这样有人就可以重建他的相关信息。”他回答道,“唉,像这样的事情在NASA内部将是一个行政官僚主义的噩梦,还是发送骨灰要容易得多。”这是人类发明的一种原始仪式……

真的是非常原始的仪式。

是啊,毫无意义。你毫无理由地破坏了关于这个人的信息。

感觉你可以从一根附在上面的棍子上得到更多的信息。

(笑) 没错。然后,外星人会说:“啊,这些人类真的很有攻击性,而且很蠢,我们可不想跟他们有任何瓜葛。”我向美国宇航局提出的建议是,发射一艘比“新视野”号运行速度更快的航天器,这样它就能超过“新视野”号,为那个盒子的事情道歉。

那可真是太有趣了。当我们想象宇宙中其他地方的生命时,我很好奇它们在形态上与地球物种十分相似的可能性有多大? 我知道我们在地球上共同的祖先,但自然界中不断出现一些新的生物形态,似乎与祖先无关。比如有蹄类动物进化成类鱼的鲸鱼和海豚,有恐龙和哺乳动物进化成有翼的鸟类和蝙蝠……

这是天体生物学的基本问题之一,是否存在一种类似于吸引子的解决方案,使得

任何形式的生命最终都与在地球上的生命相似,或者是有诸多可能性的解决方案,每一个都完全不同。如果你在地球上再次做这个实验,你会得到非常不同的生命形式。我们不知道答案。

你认为科幻小说在削弱这一科学领域的合法性方面有影响吗?

不,与之相反。几周前有一篇很有意思的论文说道,大多数选择天文学职业的人都是因为对科幻小说的迷恋。鉴于这一事实,寻找地外智慧生命的工作怎么可能不受欢迎呢? 主要是因为它没有得到联邦机构的资助,被认为是有风险。我的同事经常告诉我:非凡的观点需要有非凡的论据,这是卡尔·萨根(Carl Sagan)在七十年代说的一句话,我认为这是自我实现的预言。非凡的论据需要有非凡的资助! 如果你不为研究提供资金支持,你就永远发现不了任何东西。顺便说一下,奇怪的是,今天,发明德雷克方程(这个著名的方程声称银河系中先进科技文明的数量可以作为其他天文、生物和心理因素的函数)的科学家弗兰克·德雷克(Frank Drake)遗憾离世了。但问题是,从事探寻地外文明(SETI)工作的人对寻找地外物体很有意见。七十年来,他们一直在试图寻找无线电信号,这就像试图打电话一样,当你在听的时候,你需要有一个对方来发送信号。不管你在手机里输入多少个电话号码,你都不可能跟沃尔夫冈·阿玛多伊斯·莫扎特(Wolfgang Amadeus Mozart)通话,因为这个人已经不在世了,他已经死了。所以,如果那些传输无线电信号的文明已经不再存在,或者不再传输信号了,因为他们已经转向使用一些更先进的通信技术,那么你就永远捕捉不到那些信号,它们发生于十亿年前,又远在几十亿光年之外。所以,这未必是寻找外星智慧生命的最佳途径。然而,尽管如此,从事了七十年无线电信号搜索工作的SETI团体,如今对搜索物体的思路充满故意。我不明白为什么。

不会吧,真的吗?

我真的觉得这很令人吃惊。我没有想到会是这样。

我的最后一个问题是:如果你有一个装在瓶子里的精灵,你可以许一个愿望,你会想要万物理论还是发现外星智慧生命?

发现外星智慧生命,因为它可能会包含许多其他问题的知识。这就像站在一个聪明绝顶的同学的肩膀上望出去。我们可以找到基本问题的答案,发现新的物理学……我认为这将会是我们重新理解现实的关键。

编译 Xiuqi

AVI LOEB

Interview: Zac Bayly

Theoretical physicist and Harvard University astronomer Abraham (Avi) Loeb is on a mission to discover the living wonders of the universe — as in, those living outside of earth's atmosphere. While the search for prebiotic molecules and signs of microscopic life on other planets and moons within our solar system is a widely accepted scientific endeavour, the search for complex extraterrestrial life and indeed alien civilisations (past or present) has long been consigned to fringe science and science fiction. Avi believes this should be the case no longer. In 2021 he released two visionary books on the topic. The first, *Extraterrestrial: The First Sign of Intelligent Life Beyond Earth*, passionately argues that the peculiar nature of the interstellar object called 'Oumuamua that passed through our solar system in 2017 suggests it was neither comet or meteor, but rather something designed by another civilisation. The second, *Life In The Cosmos: From Biosignatures To Technosignatures*, is a comprehensive analysis of the many possibilities for discovering life in the universe — a text book for the burgeoning field of astrobiology. Having been the longest serving Chair of Harvard's Department of Astronomy from 2011 until 2020, he is now the Head of the Galileo Project, which aims "to bring the search for extraterrestrial technological signatures of Extraterrestrial Technological Civilizations (ETCs) from accidental or anecdotal observations and legends to the mainstream of transparent, validated and systematic scientific research." How exciting!

Zac Bayly: Hello!

Avi Loeb: Hey Zac.

Zac Bayly: How are you?

Avi Loeb: I'm doing well. Where are you in Australia now?

Zac Bayly: I'm in Sydney, and funnily enough I've flown here to shoot one of the cover stories for this issue.

Avi Loeb: Oh, okay! What is it about?

Zac Bayly: It's a science fiction-inspired fashion story.

Avi Loeb: Oh, I see!

Zac Bayly: One of the things I wanted to talk about is about your thoughts on science fiction.

Avi Loeb: Well, speaking about science fiction... Tomorrow the Venice Film Festival is going on, and they've told me there will be a 'Meeting with 'Oumuamua' — the object from interstellar space that I wrote a book about — in honour of the Italian translation of my book. They had 23 film projects submitted by first year students of the [renowned Verona film school] Side Academy all inspired by my book.

Zac Bayly: Amazing! What other kinds of people have reached out to you since *Extraterrestrial* came out?

Avi Loeb: I had about 1700 interviews over a year and half since the book... I had about, I would say, 50 — five zero — film producers and documentary-makers that contacted me

with interest in making a documentary or a film about it. That gives you an impression of how much interest there has been. In addition to that of course I just finished the follow-up book and it will come out in June 2023.

Zac Bayly: May I ask what that's about?

Avi Loeb: It's about the future of humanity and how it relates to extraterrestrial intelligence. Recently there was a lot of interest in another object [CNEOS 2014-01-08] I discovered two years later, after 'Oumuamua was reported. It turns out there was a meteor that was the first [interstellar object detected in our solar system] because it was detected on January 8th 2014, whereas 'Oumuamua was October 19th 2017. So, 'Oumuamua was almost four years later. 'Oumuamua we detected based on the reflection of sunlight, and it was the size of a football field — you know, a very big thing.

Zac Bayly: And flat like a pancake, right?

Avi Loeb: Yeah, it had the unusual properties. It was most likely flat, based on the reflection of sunlight, and moreover it was pushed away from the sun by some mysterious force, without showing a comet or a tail. In 2019 there was another object called '2020 SO' that shared the same qualities — it was pushed away from the sun by reflecting sunlight but had no comet or a tail, and it ended up being a rocket booster launched in 1966 by NASA.

Zac Bayly: Oh amazing.

Avi Loeb: It was discovered by the same telescope in Hawaii, Pan-STARRS. We know that this one was artificial because we produced it. The question is: who produced 'Oumuamua?

Zac Bayly: Yes.

Avi Loeb: So that's 'Oumuamua, but then if you go back to the 2014 meteor, it was an object the size of a watermelon. Much smaller by a factor of 200. The only reason we could see it, even though it was so small, is because it burned up in the Earth's atmosphere and collided with the Earth. You should think of the Earth as a fishing net: it moves through space around the sun and then every now and then it collides with an object. The meteor burned up in the lower atmosphere of the Earth and disintegrated, but it was an outlier because it was tougher than all the other meteors in the same catalogue. It was twice tougher than iron, so that was very unusual. Moreover, we calculated that it was moving outside of the solar system faster than 95% of all the stars in the vicinity of the sun. So, it was clearly an outlier and the interesting question is whether it was natural in origin or maybe artificial. When it disintegrated the fragments from it fell about a hundred miles off the coast of Papua New Guinea, so we are planning an expedition to search the ocean floor there. Most likely we will find tiny fragments the size of dust particles. But there is a chance that maybe something remains from the main body, from the main object, and if we find it, if we see some buttons on it, I would love to press one of these buttons. [Laughs]

Zac Bayly: [Laughs] This is one thing that I find interesting about Fermi's paradox [which describes the conflict between the lack of clear, obvious evidence for extraterrestrial life and various high estimates for their existence summed up with the question "but where is everybody?"] is that if this object had hit the same spot in the ocean 20 or 30 years ago perhaps we wouldn't have detected it, right? We're very recently able to see a little bit more clearly.

Avi Loeb: Exactly. The point is that only over the past five years astronomers discovered interstellar objects—objects that came from outside the solar system. I'm talking about big objects, not dust particles.

Zac Bayly: And presumably their arrival hasn't just magically coincided with us developing the technologies to spot them, right?

Avi Loeb: Yeah, it's just because we now have the ability to detect them. Before that, we didn't. So, when Enrico Fermi said, "Where is everybody?" he didn't really have the instrumentation, the telescopes to look through the window. He was sitting in the living room and saying, "I don't see my neighbours".

Zac Bayly: [Laughs] My blinds are shut but I can't see my neighbours.

Avi Loeb: Yeah, you better look through your windows and you better use a high-quality telescope to see your neighbours. Just over the past five years we discovered the first interstellar objects that came from beyond the solar system, and the first two were unusual. That was the meteor that we just talked about in 2014 and the second was 'Oumuamua. Both of them looked like outliers, they were anomalies. And I say if the first objects you find look weird then maybe we are missing something about our cosmic neighbourhood.

Zac Bayly: Right, right.

Avi Loeb: Let me give you two examples. A hundred years ago it was thought that the sun was made of the same material as the Earth. And then a young scientist named Cecilia Payne-Gaposchkin decided to do her first doctoral thesis in astronomy at Harvard University, and she concluded that the sun is made mostly of hydrogen, actually, not of the rock that the Earth is made of. And that was contrary to the common belief, and in fact—

Zac Bayly: What year was this?

Avi Loeb: Her PhD was 1925.

Zac Bayly: Oh, so not even a hundred years ago.

Avi Loeb: Yeah, 98 years ago, 97 years ago. One of the most distinguished astronomers at the time was on her thesis committee, his name was Henry Norris Russell, he was the director of the Princeton University Observatory, and he said, "This is impossible, you should take this statement out of your thesis." And she was a young, female scientist and she said, "Okay well I'll take it out", you know, because otherwise she wouldn't get her PhD. And she took it out but then for four years he collected his own data and analysed it and then concluded after four years that she was correct, that she was right.

Zac Bayly: Actually, I remember reading about this and I remember thinking "What an asshole".

Avi Loeb: Yeah, what an asshole. And then the second story is in 1933 an astronomer in his thirties named Fritz Zwicky, he discovered that most of the matter that you find in clusters of galaxies cannot be the matter that we see in the solar system, the ordinary matter that we are made of.

Zac Bayly: Are you referring to dark matter?

Avi Loeb: Yeah, he was the first to argue that there is dark matter in the universe. And then for 40 years he was ridiculed, including in his own institution, Caltech. This idea of dark matter was completely dismissed. They said, "No, we know what matter exists, we see it in the solar system, there is nothing else". And only 40 years later people started taking it more seriously, and now of course it's the folklore. But we still don't know what it is. It's 80% of all the matter in the universe and we don't know what it is. So that's the second story. And the third part of the story is the interstellar objects that we discovered over the past five years. The first two of them did not look like the rocks we had seen in the solar system. So, I say, you see this story coming back again and again. The sun's not made of the same material as the Earth. Most of the matter in the universe is not what we find in the solar system. Then those interstellar objects do not appear to be similar to the rocks we found in the solar system until now. I say we should be open-minded to surprises.

Zac Bayly: Right, right. Given life on our planet and how little we know about the universe outside of the solar system — our one example is a solar system that contains an abundance of life on a planet, which would suggest that there is potentially a lot of other places out there that are similar, right?

Avi Loeb: Right, yeah, so now we know something that was not known a decade ago, and that is, based on the Kepler satellite data, we know that somewhere between a few per cent up to a hundred per cent of all the sun-like stars — stars that look like our sun — somewhere between a few per cent and a hundred per cent of them have a planet the size of the Earth, roughly at the same separation. So, you basically roll the dice of life, of intelligent life, tens of billions of times in the Milky Way galaxy alone, so even if the chance is small —

Zac Bayly: It probably exists a lot, right?

Avi Loeb: Yeah, and given that most of the stars that were born billions of years before our sun, I say that it's very likely that there were scientists smarter than Albert Einstein on an exoplanet around another star a billion years ago before us, long before us. And the civilisations, the technological civilisations that benefitted from their wisdom could have sent probes that would have reached us by now. Even if they used just chemical propellants, they could have traversed and crossed the interstellar distances throughout the Milky Way galaxy by now and reached our vicinity. So, are we living in a reality where we have probes near us that we can find from other civilisations? It's not a philosophical question; this is a question that we can answer using telescopes, just looking around. That's the rationale behind the Galileo Project that I established a year ago.

Zac Bayly: This is one thing that I'm curious about—the resistance to these kinds of ideas when actually this is a science. This isn't science fiction, this is about saying these are possibilities, let's explore them.

Avi Loeb: Exactly.

Zac Bayly: I'm curious to know what resistance you're meeting in the scientific community.

Avi Loeb: Well, just to repeat what you said, if you look at the write-up that I sent you from the Venice Film Festival, at the end of it they asked me 'what message would you like to send about the future that awaits us, to young students like those at Side Academy', and my

message is simple: what was considered science fiction in the past may become science in the future. That's what I told them.

Zac Bayly: I mean if you predicted mobile phones a hundred years ago you would seem insane, you know?

Avi Loeb: Yeah, and if you imagine a cave-dweller going to New York City and looking at all the gadgets that are available, the cave-dweller would never be able to reverse-engineer anything. If we encounter technological equipment that is far more advanced than we are, that's the most likely situation. Because our modern science and technology is just a century old, and that's a small fraction of the age of the Earth or the age of the Sun. So most likely what we will encounter would be far more advanced than we are. It could also be that there are civilisations that are very primitive but to visit them we have to take a spacecraft that will carry us there which will take too many years. That is a very tedious task. It's most likely we will find a civilisation first that visits us, and there would be a technological gap. They would probably be much more advanced, and we should be open-minded because it's possible that any device will be equipped by artificial intelligence. I call this AI astronauts. They will not be biological creatures because—

Zac Bayly: A creature has to survive that travel.

Avi Loeb: Exactly. They cannot survive the long journey, the harsh conditions of space. My expectation is that we are likely to encounter something like that or some devices that are space trash, they are not operational anymore. And it's possible 'Oumuamua was just some surface layer that was torn apart from a spacecraft or something like that. It's possible.

Zac Bayly: One thing, off of that, in your Medium piece that you titled 'Interstellar Dating', you mentioned the possibility that an extraterrestrial technological civilisation could be so advanced that after an encounter we might be 'ghosted', which to me implies that they are so advanced that they can go anywhere in the universe and they've seen life on so many places that we are unremarkable.

Avi Loeb: Exactly. It's sort of like ants on the sidewalk seeing a biker that passes by. The biker wouldn't care less about a specific colony of ants. We came very late to the cosmic play. The universe existed for about 13.8 billion years. We just came at the end.

Zac Bayly: Do you think if another species or civilisation were so advanced it might be akin to us studying lower intelligences here on Earth, like cephalopods or cetaceans or corvidae or something like that, where it's kind of like they show signs of intelligence. They're not like us, but—

Avi Loeb: Yeah, you know, I'm not sure we are that intelligent. One reason I'm searching for intelligence in space is because I don't find it often here on earth.

Zac Bayly: [Laughs] Right.

Avi Loeb: One sign of us not being intelligent is that there was this New Horizons spacecraft that was sent by NASA to study Pluto, and they decided to celebrate Clyde Tombaugh, the scientist who discovered Pluto. They celebrated him by attaching a box with 30 grams of the ashes of Clyde Tombaugh to the New Horizons spacecraft. Now, imagine extraterrestrials finding this box. They would say, "It makes no sense, these humans are really strange

because they destroyed the genetic information by burning up the DNA of a human that they want to commemorate." You know, these ashes are just like the ashes of a cigarette.

Zac Bayly: Did we really do that?

Avi Loeb: We did that! It was done by a scientific organisation called NASA.

Zac Bayly: No.

Avi Loeb: And the project, New Horizons, was led by a principal investigator who I know, who is also a member of the Galileo Project, his name is Alan Stern. I approached him and I said, "Alan, why did you do that? It makes no sense, you should have sent an electronic record of the DNA of Clyde Tombaugh. That would have some information content, so someone can reconstruct him." And he said, "Well anything like that would have been a bureaucratic nightmare within NASA. It was much easier to send the ashes." This is a primitive ritual that humans invented...

Zac Bayly: It is a very primitive ritual.

Avi Loeb: Yeah it makes no sense. You destroyed information about the person for no good reason.

Zac Bayly: It feels like you could get more information from a stick that you attach to it.

Avi Loeb: [Laughs] That's right. So, the extraterrestrials will say, "Oh these humans are really aggressive and not intelligent, we don't want anything to do with them." My suggestion to NASA was to send a spacecraft that moves faster than New Horizons so that it will overtake it and apologise for the box.

Zac Bayly: That's very, very funny. When we imagine life in other parts of the universe, I'm curious to know what the chances are of it actually being very similar in form to earth species? I know that we have common ancestors on earth, but there are forms that keep appearing in nature, seemingly regardless of the ancestor. We've had hooved animals that have evolved into fish-like whales and dolphins, we've had dinosaurs and mammals evolve into winged birds and bats...

Avi Loeb: This is one of the fundamental questions of astrobiology, whether there is one solution that is sort of like an attractor that any form of life ends up being similar to the one realised on Earth, or whether there are many possible solutions, each of them completely different, and if you were to do the experiment again on Earth you would end up with very different forms of life. We don't know the answer to that.

Zac Bayly: Do you think science fiction has played a role in delegitimising this area of science, the search for extraterrestrial life?

Avi Loeb: No, it's the other way around. There was an interesting paper a few weeks ago saying that most people who chose a career in astronomy did that because of a fascination with science fiction. Given that fact, how is it possible that the search for extraterrestrial intelligence is not that popular? It's not funded by federal agencies, it's considered risky. My colleagues often tell me: extraordinary claims require extraordinary evidence, which is a statement made by Carl Sagan in the seventies, and I say this is a self-fulfilling prophecy. Extraordinary evidence requires extraordinary funding! If you are not funding the search you will never find anything. By the way, the strange thing is, today, sadly, Frank Drake, who

developed the Drake equation [the famous equation that purports to yield the number of technically advanced civilizations in the Milky Way Galaxy as a function of other astronomical, biological, and psychological factors], passed away. But the point is the people who worked on SETI have a problem with the search for extraterrestrial objects. For seventy years they tried to look for radio signals and it's just like trying to have a phone conversation, you need a counterpart to be transmitting when you're listening. It doesn't matter how many phone numbers you put in your cell phone you will never speak with Wolfgang Amadeus Mozart, he's not alive anymore, he died. So, if those civilisations that transmitted radio signals are not around anymore or are not transmitting anymore because they moved on to some much better technologies for communication, you will never see those signals, they are billions of light-years away, they were generated a billion years ago. So, it's not necessarily the best method to find extraterrestrial intelligence. Yet, nevertheless, the SETI community that was engaged in searching for radio signals for seventy years, they are hostile today to the idea of searching for objects. I don't understand why.

Zac Bayly: No, really?

Avi Loeb: I found that really surprising. I didn't expect that.

Zac Bayly: My final question is: If you had a genie in a bottle, and you could make one wish, would you want the theory of everything or the discovery of ETI?

Avi Loeb: Discovery of extraterrestrial intelligence because it may encapsulate a lot of knowledge about the other questions. It's like looking over the shoulder of a class mate that is much more intelligent than we are. We can find answers to fundamental questions, new physics... I think it would hold the key to a completely new understanding of reality for us.