57th IMO HONG KONG 2016

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數聞 IMOment

笑一笑 LAUGH OUT LOUD

挑戰園地 CHALLENGE CORNER

數學與象棋
MATHEMATICS AND CHESS

JACOB LURIE ：欲速則不達
Jacob Lurie: Firm and Patient Steps

領隊於 IMO 2015 之見聞 (下)
IMO 2015 REPORT -- LEADER'S PESPECTIVE (II)

2016 年第五十七屆國際數學奧林匹克籌備委員會
Organising Committee of the 57th International Mathematical Olympiad 2016

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2016 年第五十七屆
國際數學奧林匹克籌備委員會

香港將於 2016 年 7 月舉辦第五十七屆國際數學奧林匹克（IMO），迎接來自超過 100 個國家的中學生數學精英。希望《數聞》可在我們邁向 2016 年 IMO 期間帶動同學和公眾對數學的興趣，更希望這種氣氛歷久不衰。

歡迎讀者向《數聞》投稿。文章須為原著，以中文或英文寫成（或兩種文本兼備），長度為一至四頁（就一種語言而言），並以電郵附件方式傳送至 info@imohkc.org.hk，或郵寄至 九龍油麻地 405 號 九龍政府合署 4 樓 403 室 教育局數學教育組《數聞》編輯，標題為「Submission to IMOment」。

Hong Kong is proud to be organizing the brightest secondary school mathematics talents from over 100 countries at the 57th International Mathematical Olympiad (IMO) in July 2016. We hope that IMOment will promote interest in mathematics among students and the public in this period leading up to IMO 2016, and beyond.

Readers are welcome to submit articles on mathematics and/or Mathematical Olympiad to IMOment. Submissions should be original, one to four pages in length in either Chinese or English (or both), and should be sent by attachment to an email to info@imohkc.org.hk, or be mailed to Mathematics Education Section, Rm. 403, Kowloon Government Offices, 405 Nathan Road, Yau Ma Tei, Kowloon, titled "Submission to IMOment."

Organising Committee of the 57th
International Mathematical Olympiad 2016

第六期內容
Contents of 6th Issue

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領隊於 IMO 2015 之見聞 (下)
IMO 2015 REPORT LEADER'S PERSPECTIVE (II)

/羅家豪 LAW KA-HO

根據 IMO 的規定，領隊大會由各隊的領隊及一位由主辦國派出的主席所組成。基本上所有有關 IMO 的事項均由領隊大會投票決定。

大會主席擔當着相當重要的角色，他（她）需具備優秀的語言能力，也要清楚知道所有程序以及控制大會討論的進程。

領隊大會其中一個重要的議程是挑選並整理兩天的比賽題目。在兩份試題修訂好後，領隊會翻譯成自己國家的語言。但港隊的學生只需英文及繁體中文的試卷，我毋須進行翻譯，因為前者是官方語言，而後者則由台灣隊提供。

大會也會討論各題的評分準則。負責各題的協調員會派代表到台上介紹他們草擬的評分準則，經大會討論及修訂後以投票方式表決是否通過。

According to the IMO regulations, the Jury consists of the team leaders plus a Chairperson appointed by the host country. Basically all decisions concerning the IMO are made through voting at the Jury Meeting.

The Jury Chairperson has a very important role. (S)he needs to have excellent language skills, know the procedures well and control the pace of the meeting.

One of the main tasks of the Jury is to select the problems and form the two-day contest papers. After the two papers were fixed, leaders had to translate them into their own language. I need not do it because the students from the Hong Kong team only need the English and Chinese (Traditional) papers; the former is an official language and the latter was provided by Taiwan.

The Jury also discussed the marking scheme of each problem. Representatives from the coordinators for each problem would come up to the stage to introduce their proposal; the Jury then discussed and made amendments, and finally voted to accept the marking schemes.

除了翻譯試題外，大會所討論的內容有時也會被翻譯。會議以英語進行，但當有人提出動議或其他重要事項時，法國、西班牙、德國及俄羅斯的領隊會分別把內容翻譯成其他幾種大會語言，即法語、西班牙語、德語及俄語（但因為今年沒有領隊需要德語翻譯，故沒有提供）。以上情況出現時，大會主席會說：「請翻譯」，接著法國、西班牙及俄羅斯的領隊便會把信息翻譯成他們各自的語言。

由於部份領隊的母語並不是英語，他們之中有些英文口音讓我聽起來有點吃力。在最後一輪領隊大會上，其中一位領隊的發言讓我費盡了腦汁。話音剛落，主席看來一臉茫然，沉默了一會兒才說：「請翻譯！」。接著當法國領隊發言時，我才得知剛才那位領隊說的是法語！

領隊們需在最後一輪領隊大會上決定各獎牌的臨界分數。根據之前的協定，大會會公佈部份成績的分佈，但領隊在表決前不會知道實際的臨界分數（雖然大會已宣佈個人得分，但各隊中某些隊員的得分被遮蔽，只有該隊的領隊知道，故各領隊無法憑蠻力數算來得知確實數字）。大會首先要決定銅牌的臨界分數：要麼將它設高一分，產生共 282 面獎牌（比參賽人數的一半少 6.5），要麼調低一分以產生 306 面獎牌（比半數多 17.5）。結果前者獲明顯的過半數支持通過。

Apart from translating the contest papers, the contents of the Jury Meeting were also translated from time to time. While the Jury Meeting was held in English, translations to other official languages (French, Spanish, German and Russian) would be provided by the leaders of France, Spain, Germany and Russia when a motion was put or when there were other important messages. (But this year no leader required any German translation so it was not provided.) When this happened the Jury Chairperson would say `Translations please', and then the French, Spanish and Russian leaders would translate the message into the respective languages.

As English is not the first language for many leaders, some of them speak with an accent which, for me, would take some effort to understand. At the Final Jury Meeting, when a certain leader spoke, I had a hard time understanding what he was talking about. When he finished, the Jury Chairperson looked puzzled, paused a few seconds, and eventually said, `Translations please'! Then when the French leader spoke, I finally realised that the previous leader was speaking in French!

At the Final Jury Meeting, the cutting scores were decided. According to the agreed protocol, some distributions would be shown while the leaders would not know the exact cutting score (the individual scores were already announced but some in each team were hidden and known only to the leader of the team, making `brute force counting' impossible). We first had to decide the bronze cut-off, which was pretty clear since we either award a total of 282 medals (6.5 less than than half the total number of contestants) if we set the bronze cutting score 1 point higher, or 306 (17.5 more than than half) if the cutting score were 1 point lower. The former was adopted with a clear majority.

銀牌的臨界分數亦十分清晰。在最理想的分佈下，金牌及銀牌的總數應是 141（即 282 的一半）。以某分數（實際數字當時不作公佈）作分界共會產生 139 面金牌和銀牌，但若設低一分便會得出 159 面金牌和銀牌。同樣地，前者獲大部份領隊支持而被採納。

然而，金牌的臨界分數卻惹來不少爭議。若金牌和銀牌的比為 1：2，那麼我們應頒發 139 ÷ 3 = 46 又 1/3 面金牌。如果考慮到金、銀、銅牌的比應為 1：2：3，那麼最理想的分佈應設 282 ÷ 6 = 47 面金牌。由於參賽者的得分是離散的，我們只能有 39 或 54 位金牌得主，這兩個選擇顯然都未如理想。事實上，持不同意見的領隊當時便各自提出一些「數學觀點」來說明為何他們所支持的選項較佳（有興趣的讀者不妨嘗試構作這樣的論據）。最後，大會以投票方式表決，結果由頒發39面金牌（即把金牌的臨界分數設高一分）的選項險勝。

IMO 大會的規則並沒有詳細說明有關投票的程序，只表明「議案在大會上以簡單多數制投票通過」。按照傳統，當有多個選項時，大會會以淘汰的方法表決，即每次淘汰得票最少的選項，直至只餘下一個選項為止。

The silver cutting score was also clear. In the perfect case there should be 141 gold and silver medals (half of 282). A certain cutting line (exact score not revealed yet) would result in 139 gold and silver medals, while the number would jump to 159 if the cutting score were 1 point lower. Again, the former was adopted with a clear majority.

The gold cutting score led to more controversy. If one tries to make the number of gold and silver medals in the ratio 1:2, then 139÷3 = 46-and-a-1/3 gold medals should be awarded. Or, considering the 1:2:3 ratio between gold, silver and bronze, there should ideally be 282 ÷ 6 = 47 gold medals. However as the scores are discrete, we could either award 39 or 54 gold medals. The two sides seemed to be `equally unsatisfactory'. In fact, leaders supporting different options spoke to argue why one of them is mathematically better than the other. (The interested reader may try to work out some such arguments!) This went into voting in the end, and Jury chose to award only 39 gold medals (i.e. to take the higher cutting score for gold) by a very narrow margin.

The IMO regulations did not specify in great detail the exact rules for voting. All it says is that `a motion is carried by a simple majority of those voting'. As a tradition, whenever several options are present, the winning option is chosen by repeated elimination, i.e. eliminating the option with the fewest vote each time until the winning option emerges.

但這些規則並沒有被嚴格遵守。例如，當選項過多時，主席會建議於首輪投票中可能先淘汰8個選項，次輪再淘汰 5 個選項，然後才逐一淘汰。然後某位領隊又可能說這太多了，或許在首輪只淘汰 5 項會更理想，等等。在我看來也實在是有點太過隨意了。有時候，有 3 項選項時，某位領隊會突然提出「採納第一個選項」的動議，然後大家就此建議進行投票並通過議案。但很明顯，部份成員對不同的選項並沒有強烈的取態，因此如果大家就「採納第二個選項」作表決，或許也會被通過（因為反對票不足，部份成員可能會分別對兩項選項投贊成票）。當面對多個選項時，有領隊甚至會提出：「最後 4 項明顯不好，所以我動議只考慮首 4 項」。

如果我們使用淘汰選項的方法，實在有必要清晰說明當出現兩個或以上獲得相同最低票數的選項時應如何處理。這情況今年發生過一次，結果主席顯然很隨意地決定把兩個獲得最低票數的選項同時淘汰。

最令我困惑的是以下這項動議。IMO 規定所有獎牌得主的總數不得多於參賽者的半數。但其實歷年來多次出現違反這規定的情況（例如，考慮到分數的離散分佈，有些時候領隊大會會議決頒發更多的獎牌）。今年，有人建議需要三分之二的大會成員（並非只是投票者！）投贊成票才能通過違反以上規定的決議。這項動議（即改變投票制度至獲三分之二人贊成才能通過特別決議）表決時在簡單多數制下以些微票數之差獲通過。大家應可看到當中的矛盾之處 — 若成員認為在重要議案上不應只靠簡單多數票通過的話，那麼「更改投票制度」一項應屬重要議案，實在不應以簡單多數票來通過。

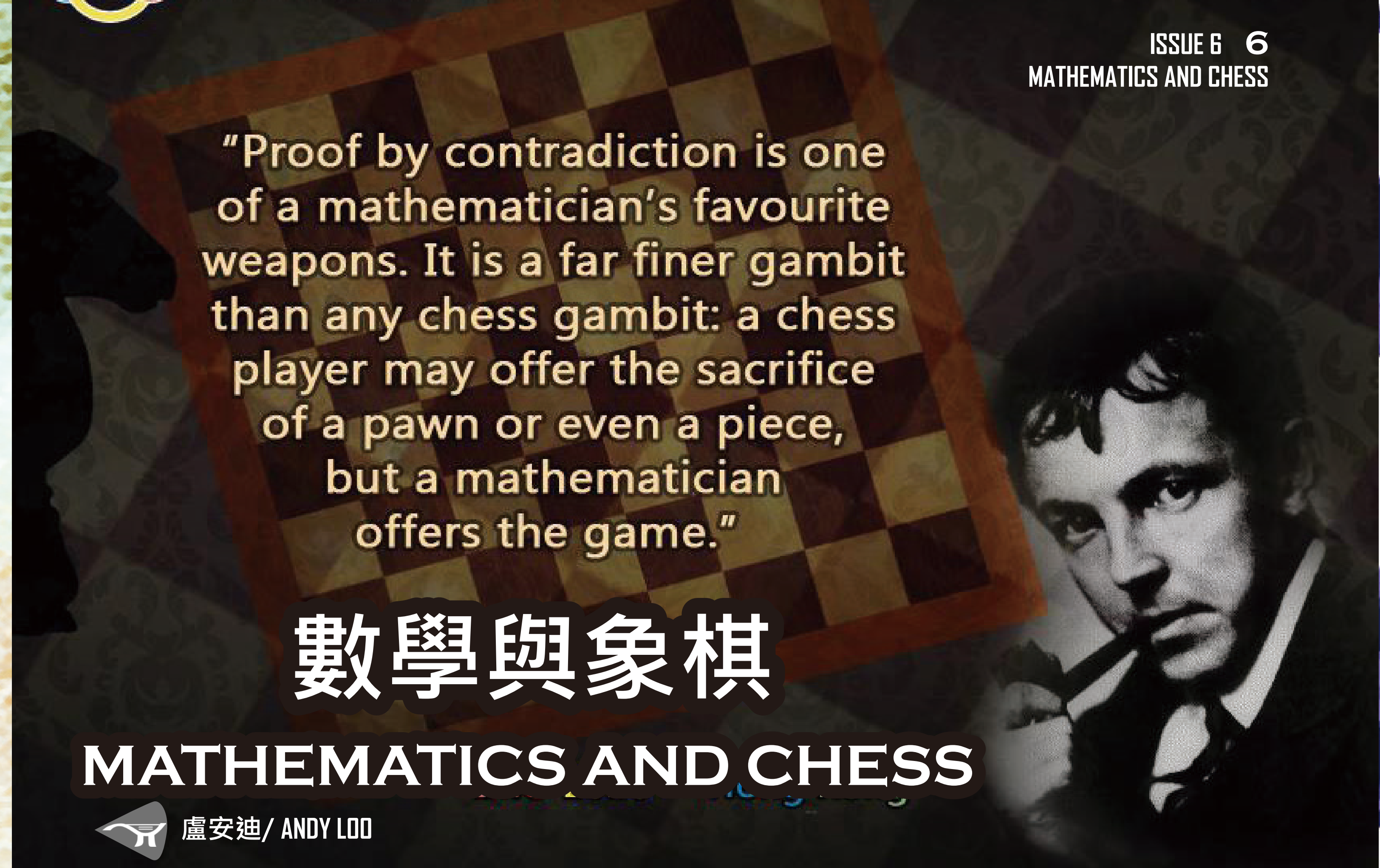
我一直十分重視規則中的「魔鬼細節」，事實上一個看似微小的轉變可能會大大影響最終結果。我希望有朝一日會有一套較為嚴謹的規則來控制投票程序。

However, these rules were not always strictly observed. For example, when too many options exist, the Chairperson might suggest, say, eliminating 8 options in the first round, 5 in the second, and then one by one. Then another leader said that's too many; perhaps eliminating 5 in the first round would be better. Things just seemed too random. Sometimes when three options exist, a leader may suddenly propose a motion `to adopt Option 1', and then it was carried after voting. However, it was quite clear that when some Jury members do not have a strong opinion among the options, then another motion `to adopt Option 2' could equally have been carried (because there won't be enough votes against, while some Jury members will support both motions). Or sometimes when many options exist, a leader may say `clearly the last four are not good, so I propose to consider the first four only'.

When voting by elimination was used, it is important to specify what to do when there were two or more options with an equal number of (lowest) votes. This happened once during the Jury Meetings, and the Chairperson decided (apparently quite randomly) to eliminate both.

There was one motion that puzzled me the most. According to IMO regulations, not more than half of the contestants may get medals. However this rule had been violated from time to time in the past (for instance the Jury might want to award medals to slightly more than half of the contestants owing to the discrete nature of the scores). This year, it was proposed that violating this rule would require a motion carried by a majority representing two-thirds of the Jury members (not of those voting!), and this motion itself (on changing the rule to requiring two-third-majority) was carried by simple majority (with a narrow margin). You see the contradiction here --- if the Jury was of the opinion that something important should require more than a simple majority, then `changing the rule' should be regarded as something important and should not be passed with just a simple majority.

I have long been of the opinion that the details of the rules are very important. A minor change could easily have led to a different outcome. I would definitely want to see a more rigorously written set of rules that govern the voting procedures.



"Proof by contradiction is one of a mathematician's favourite weapons. It is a far finer gambit than any chess gambit: a chess player may offer the sacrifice of a pawn or even a piece, but a mathematician offers the game."

數學與象棋

MATHEMATICS AND CHESS

盧安迪/ ANDY LOO

在2016年國際數學奧林匹克 Facebook 專頁（facebook.com/imo2016）的 IMO Idea #44 中，我們介紹了數學家哈代的名言：

> 反證法是數學家的拿手好戲。它比任何棋手棄子取勝的策略都更高明：棋手可能願意丟車保帥，但數學家卻是把全盤置諸死地而後生。

在該圖片的描述中，我寫道（以下譯自英文）：

> 設想一個國際象棋遊戲，每方每次可走兩步（而非一步）。白方（先走的一方）有必不敗策略。何解？

如果白方沒有必不敗策略，則黑方有必勝策略。那麼，白方在開局的兩步，可先把一隻棋子走到某處，再把那隻棋子走回原位，使得經過這兩步後，所有棋子都在原位（即棋盤局面跟開始前無異）。這時，白方的角色等如黑方在遊戲開始時的角色（後走的一方），故根據段首的假設，白方有必勝策略──矛盾！

IMO Idea #44 on the IMO 2016 Facebook page (facebook.com/imo2016) features the following quote of mathematician G. H. Hardy:

> Proof by contradiction is one of a mathematician's favourite weapons. It is a far finer gambit than any chess gambit: a chess player may offer the sacrifice of a pawn or even a piece, but a mathematician offers the game.

In the caption of that picture, I wrote:

> Imagine a chess game where each player makes two moves (instead of one move) at a time. White (the side moving first) has a non-losing strategy. Why?

Well, if white doesn't have a non-losing strategy, then black has a winning strategy. Then white can begin by moving a piece somewhere and then moving it back to its original position, so that after the two moves all pieces are at their original Positions (i.e. the game returns to the starting state). At this point, white is just like black in the original game (being the side to move second), so by the assumption, white has a winning strategy – a contradiction!!!

該帖子發表後，我博學多才的朋友──同時也是《數聞》的另一編輯──羅家豪博士向我指出了上述證明中一個微妙的漏洞：國際象棋的「三次重複規則」規定，如果同一局面（各棋子的位置）出現三次，棋手便可要求和局。因此，白方走了兩步後，並不完全等如黑方在遊戲開始時的角色！讀者可以想想如何補救這個證明（如果可能的話）。

關於「三次重複規則」，另一點亦值得注意：由於棋盤上每隻棋子只有有限個可能停駐的格子，因此局面亦只有有限個不同的可能性，所以不存在無限長而任何局面均沒有三次重複的棋局。故此，「三次重複規則」保證了任何棋局最終都可結束。

然而，人們也提出了另一個象棋規則（其實在中國象棋中便有這樣的規則）：如果在同一局面中的一連串走法連續出現三次，棋局即告結束。以下，每當我們提述「一連串走法的重複」，我們指的是在同一局面中的一連串走法的連續重複（注意是連續！）。當然，如果有一連串走法三次重複，也就有某局面三次重複，但前者是一個更強的條件（也更少出現）。我們可以問：是否可能有一盤無限長的棋局，不包含一連串走法三次重複？

其實，我們可以先考慮一個更簡單的問題。如果一個 0-1 數列（每項為 0 或 1）沒有一連串的項連續三次重複，我們便說它是「無三重」的。例如 1101 是無三重的，但 111 及 101010 則不是無三重的。那麼，有沒有一個無限長，而又無三重的 0-1 數列？

答案是肯定的。以下是一個例子：

- 第 1 項為 0。
- 若 n 被 3 整除，則第 n 項為 0。
- 若 n 被 3 除餘 2，則第 n 項為 1。
- 若 n 被 3 除餘 1，則第 n 項等於第 $\frac{n-1}{3}$ 項。

After the post was released, my learned friend – and IMOment co-editor – Dr. Law Ka-ho pointed out to me a subtle flaw in the above proof: the threefold repetition rule in chess states that a player can claim a draw if the same Position occurs three times. Here, the term "Position" means the positions of all chess pieces, consider it as a snapshot of the chessboard after a certain move. Thus, having made two moves, white is not really in the same situation as black in the original game! The reader may try to figure out how to fix the proof, if it is possible.

Another observation about the threefold repetition rule is as follows: Since every chess piece can only land in finitely many squares, there are only finitely many Positions in chess, so it is impossible to have an infinitely long chess game without threefold repetition. Therefore, the threefold repetition rule ensures that any chess game can eventually end.

However, people have also proposed another chess rule (which is a rule of Chinese chess, for example): If the same sequence of moves in the same positions occurs three times in a row, the game shall end immediately. From now on, when we talk about a sequence repetition, we mean a repetition of a sequence of moves in the same positions and in a row (remember: in a row!!!). Note that a threefold sequence repetition implies a threefold position repetition, but the former is a stronger condition (and hence less likely to happen). We may ask: can there be an infinitely long chess game that does not include any threefold sequence repetition?

In fact, we can begin with a simpler question. A 0-1 sequence (each term being 0 or 1) is said to be tripleless if no string of consecutive terms appears three times in a row. For example, 1101 is tripleless but 111 and 101010 are not tripleless. Then, is there an infinitely long tripleless 0-1 sequence?

The answer is yes, and the following is an example:

- The 1st term is 0.
- If n is divisible by 3, the n^{th} term is 0.
- If n leaves a remainder of 2 when divided by 3, the n^{th} term is 1.
- If n leaves a remainder of 1 when divided by 3, the n^{th} term is the same as the $\left(\frac{n-1}{3}\right)^{th}$ term.

於是，我們得到以下數列：

010 010 110 010 010 …

除此之外，還有另一個有趣的無三重的 0-1 數列。首先，對於一個 0-1 數列，若把所有 0 變成 1，把所有 1 變成 0，便得到它的「補充數列」。現在，我們由一個 0 開始，每次在後面加上現有數列的補充數列，不斷重複這個步驟：

0
0 1
01 10
0110 1001
01101001 10010110
…

讀者可否證明以上介紹的兩個無限長的 0-1 數列都確是無三重的數列？

有了一個無限長的而又無三重的 0-1 數列，我們可輕易構作一個無限長而又沒有一連串走法三次重複的棋局。設 P 為棋盤的一個局面，A、B 為兩組連串走法，兩組均以 P 開始，以 P 結束，而且 A、B 中沒有相同的走法。現在，依次逐一跟從該 0-1 數列的各項。如果某項為 0，則令對弈雙方走 A 的一連串走法。如果某項為 1，則走 B 的一連串走法。由於該 0-1 數列無限長，故這個程序可永遠繼續下去。讀者可否看出為何這樣的棋局不會有一連串走法三次重複？

So the sequence looks like this:

010 010 110 010 010 …

Apart from the above, there is another interesting tripleless 0-1 sequence. First, given a 0-1 equence, its complementary sequence is the sequence obtained by changing every 0 to 1 and every 1 to 0. Now, starting with a 0, we append the complementary sequence of the existing sequence, and repeat this step indefinitely:

0
0 1
01 10
0110 1001
01101001 10010110
…

Can the reader prove that the two infinitely long 0-1 sequences we have introduced are indeed tripleless?

We can easily construct an infinitely long chess game without any threefold sequence repetition from an infinitely long tripleless 0-1 sequence. Let P be a position and A and B be two sequences of moves that both start with P and end with P, such that the moves in A and B are all different. Now follow the terms of the 0-1 sequence one by one. If a term is 0, let the chess players play the sequence A. If a term is 1, let them play the sequence B. Since the 0-1 sequence is infinitely long, this procedure can continue forever. Can the reader see why such a chess game will not have any threefold sequence repetition?

參考

Stewart, Ian. 2006. "The Never-Ending Chess Game." In How to Cut a Cake And Other Mathematical Conundrums, 61-69. Oxford: Oxford University Press.

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Jacob Lurie：欲速則不達

Jacob Lurie：Firm and Patient Steps

盧安迪/ ANDY LOO

1996 年西屋科學大賽三甲/Awardees of the 1996 WSTS。中/Middle：Jacob Lurie
相片來源/Photo Source: student.societyforscience.org, www.math.harvard.edu/~lurie

在1994年香港主辦的國際數學奧林匹克中，美國的「夢之隊」六人全部取得滿分，Jacob Lurie就是其中一員。1996年，Lurie 在西屋科學大賽（後改稱英特爾科學大賽）贏得冠軍。在哈佛大學就讀本科期間，他獲得表彰本科生研究的Morgan Prize。他現為哈佛大學數學系教授，並於2014年成為首屆數學突破獎的得主之一。

Jacob Lurie was part of the USA "Dream Team" all of whose members got perfect scores at the 1994 IMO hosted by Hong Kong. In 1996 he took first place in the Westinghouse Science Talent Search (later renamed Intel Science Talent Search). During his undergraduate studies at Harvard, he won the Morgan Prize for undergraduate research. He is now a professor at Havard's Math Department, and, in 2014, was awarded an inaugural Breakthrough Prize in Mathematics.

AL = 盧安迪
JL = Jacob Lurie教授

AL = Andy Loo
JL = Jacob Lurie

AL：Lurie 教授，你是怎樣發掘對數學的興趣的？

AL: Professor Lurie, how did you discover your interest in mathematics?

JL： 記得小時候，我問母親最大的數字是什麼。她去研究了一下，然後回來告訴我最大的數字是一個古戈爾（10^{100}）。這個答案令我十分高興，因為只需學會數到一個古戈爾，我就學會所有數學了。

JL: Once, when I was young, I asked my mother what the biggest number was. After doing a bit of research, she came back and told me that the answer was a googol (10^{100}). This was a very satisfying answer; all I needed to do was learn to count to a googol, and then I could be done with mathematics.

AL：你為何喜歡數學？

AL: Why do you like mathematics?

JL： 根據我的經驗，思考數學是會上癮的：當你學到不同範疇間千絲萬縷的關係，以及它們錯綜複雜的精妙結合，你便會越加好奇。我是幸運的，因為作為教授，我可以藉我的愛好為生（無論如何，我都不能抗拒數學的誘惑）。

JL: My experience has been that thinking about mathematics is addictive: the more you learn about the tightly interwoven stories of various subjects and the intricate ways that various pieces fit together, the more you want to learn. I consider myself very fortunate that it's actually possible to get paid to do what I do (since I probably wouldn't be able to resist doing it anyway).

AL：你在高中和現在分別最喜歡哪些數學範疇呢？

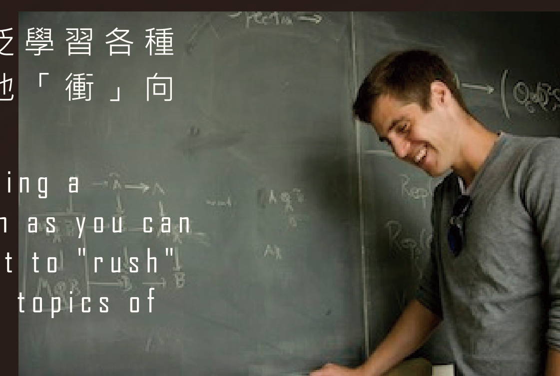
AL: Which areas of math were/are you most interested in in high school, and now, and why?

JL： 在高中，我對數學邏輯深感興趣（尤其是可計算性理論）。現在，我的主要領域是拓撲學和代數幾何。我在大學本科時修讀了幾個十分精彩的代數幾何課程，堪稱我大學生涯的亮點。

JL: In high school I was very interested in mathematical logic (particularly computability theory). Now, my main interests are topology and algebraic geometry. I took several really excellent courses in algebraic geometry in college; they were the highlight of my undergraduate experience.

對有意成為數學家的高中同學，我建議你們廣泛學習各種領域的知識，越多越好。我也建議不要太心急地「衝」向最新的研究成果或前沿課題。

To a high school student interested in becoming a mathematician, my advice would be to learn as much as you can about a broad range of subjects. I'd also advise not to "rush" toward learning about the latest developments or topics of current research interest…



AL：你在高中的數學活動學到最重要的東西是什麼？它們有影響你的工作生涯嗎？

AL: What are the most important things you have learned from your math activities in high school (including math Olympiad)? Did they influence your career?

JL： 我在高中參加奧數活動，學到的其中一樣最重要東西，就是怎樣長時間專注思考一個問題，即使我對那問題毫無頭緒（尤其是開始的時候）。這正是一個職業數學家的日常工作（雖然現在思考的是不同類型的問題，也沒有設定的時間限制）。

JL: One of the most important things I learned from participating in the mathematics olympiad was how to focus on a question for an extended period of time, even in the case of a question that I might (initially) have no idea how to approach. This is something that a professional mathematician does every day (although for questions of a different kind and without an artificial time limit).

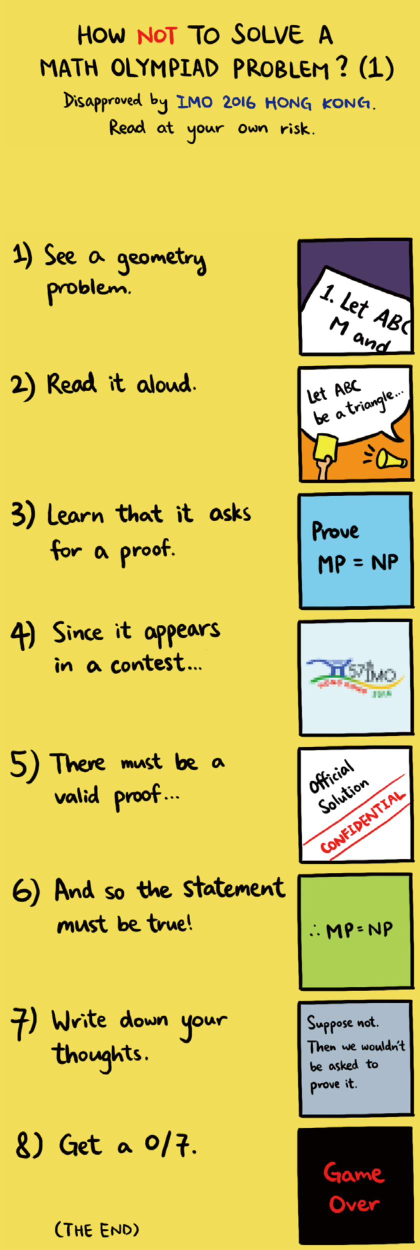
AL：如果同學們對數學感興趣，或者有志深造數學，你對他們有什麼忠告？

AL: Do you have any advice to give to high school students interested in math, and possibly aspiring to pursue further studies in math?

JL： 對有意成為數學家的高中同學，我建議你們廣泛學習各種領域的知識，越多越好。我也建議不要太心急地「衝」向最新的研究成果或前沿課題。反之，如果先瞭解數學的歷史，並明白各種想法何時出現、因何而起，那麼你便更能掌握這門學問的脈絡。

JL: To a high school student interested in becoming a mathematician, my advice would be to learn as much as you can about a broad range of subjects. I'd also advise not to "rush" toward learning about the latest developments or topics of current research interest: you're likely to get a much better understanding of the subject by studying its history, and knowing when and why various ideas were introduced.

笑一笑 Laugh Out Loud



Disclaimer: The problem in this comic is NOT necessarily a real problem in IMO 2016.

挑戰園地 Challenge Corner

第六期挑戰園地的解答及得獎名單，可見:
For the solutions and list of awardees of the Challenge Corner of the 6th issue, please see:
http://www.edb.gov.hk/tc/curriculum-development/kla/ma/IMO/IMOment.html

1. 一個古戈爾有多少個正因數？（關於古戈爾的定義，請參看本期 Jacob Lurie 教授的訪問。）

How many positive divisors does one googol have? (Please see our interview with Professor Jacob Lurie in the current issue for the definition of a googol.)

2. 考慮一個 2015×2015 的棋盤。現移除左上角那個 1×1 的小格。問餘下部分可否以 1×4 和 4×1 的長方形無重疊地密鋪？

Consider a 2015×2015 chessboard. The 1×1 square at the top-left corner is removed. Can the remaining part be tiled with 1×4 and 4×1 rectangles without overlap?

3. 求一個邊長為 5、5、6 的三角形的外接圓半徑。

Find the radius of the circumcircle of a triangle with side lengths 5, 5, 6.

4. 若 x、y、z 為正實數，滿足 $xyz = x + y + z$，求證：存在一個三角形 ABC，使得 $x = \tan A$、$y = \tan B$、$z = \tan C$。

If x, y, z are positive real numbers such that $xyz = x + y + z$, prove that there exists a triangle ABC such that $x = \tan A$, $y = \tan B$, and $z = \tan C$.

歡迎香港中、小學生讀者電郵至 info@imohkc.org.hk 提交解答（包括證明），並於電郵中列明學生中英文姓名、學校中英文名稱及學生班級。每一名學生只可發送一份電郵。首 20 名答對最多題目的同學將獲贈紀念品，但每間學校最多有 3 名同學得獎。解答可以中文或英文提交。打字及掃描文件皆可接受。得獎者將於下一期公布。2016 年第五十七屆國際數學奧林匹克籌備委員會對本活動安排有最終決定權。如有疑問，可電郵至 info@imohkc.org.hk 查詢。

Hong Kong secondary and primary school student readers are welcome to submit solutions (with proofs) via email to info@imohkc.org.hk, specifying the student's name in Chinese and in English, the school's name in Chinese and in English, and the student's class in the email. Each student may send at most one email. Souvenirs will be awarded to the first 20 students solving the most questions on the condition that each school can have at most 3 awardees. Solutions can be submitted in Chinese or English. Both typed and scanned files are acceptable. The awardees will be announced in the next issue. The decision of the Organising Committee of the 57th International Mathematical Olympiad on any matter of this activity is final. Enquiries may be emailed to info@imohkc.org.hk.