

DIAMENTY MATEMATYKI

Niezwykłe związki między liczbami mogą skłaniać do ogólniejszych refleksji, do zastanawiania się nad znaczeniem pojęcia liczby, nad naturą i potęgą matematyki. Wśród znanych wzorów, opisujących zależności wiążące ze sobą różne liczby, wybija się jeden, krótki, prosty, choć na pierwszy rzut oka wyglądający może trochę odstraszająco. Tym niemniej wielu matematyków uważa go za jedno z najpiękniejszych twierdzeń matematyki. Mowa o wzorze

$$e^{\pi} + 1 = 0$$

Cóż w nim takiego szczególnego? Dlaczego wielu matematyków sądzi, że jest on "ładniejszy" od, na przykład, niewątpliwie prawdziwego związku " $2+2=4$ "? Jeden z podstawowych argumentów, jakie się wysuwa, stwierdza, że wzór $e^{\pi} + 1 = 0$ w zadziwiająco prosty sposób łączy w sobie pięć najistotniejszych stałych matematycznych. Stałe te pojawiły się w matematyce zupełnie niezależnie, dla potrzeb różnych gałęzi tej nauki. Także i dziś, w matematyce współczesnej, definiuje się je całkiem odmiennymi sposobami - z wyjątkiem liczb 0 i 1, które w oczywisty sposób wydają się "podobne", różne od pozostałych trzech.

"Liczby naturalne stworzył dobry Bóg, a całą resztę wymyślił ludzie" - powiedział wybitny matematyk niemiecki XIX wieku, Leopold Kronecker. Liczby naturalne (czyli: 1, 2, 3, 4, ... itd.) znano od niepamiętnych czasów, jako że mają one związek z praktyczną działalnością człowieka, czyli liczeniem przedmiotów. Wielu matematyków zalicza do liczb naturalnych również 0.

Zero pojawiło się w historii zaskakująco późno. Starożytni Grecy, którzy ogromnie przyczynili się do rozwoju matematyki, nie znali pojęcia zera, co bardzo powadnie komplikowało ich sposób zapisywania liczb. Zmudną i niełatwą pracę stanowiło wykonywanie działań. Podobnie było przy użyciu rzymskiego systemu zapisu liczb. Jeśli ktoś ma wątpliwości, niech pomnoży przez siebie dwie liczby: CCCLX i DXXXIII - ale bez tłumaczenia na układ dziesiętny. Zero wprowadzono, wraz z liczbami ujemnymi, w Indiach (VI-VIII wiek n. e., choć podobno Chińczycy znali je wcześniej). Hindusi rozpowszechnili też system pozycyjny zapisywania liczb, choć przypuszczają się, że początkowo korzystali jedynie z dziesięciu cyfr odpowiadających naszym cyfrom od 1 do 9, zera zaś zaczęło używać znacznie później; nazywali je sumya, co miało znaczyć "pusty" lub "próżny". Dziesiętny system pozycyjny wraz z zerem przejęli od Hindusów Arabowie. Zwrot "pusty" przetłumaczyli mniej więcej na as-sifr, co z kolei przetłozono na łacinę jako zephyrum. Od tego wyrazu wywodzi się słowo "zero", a także "cyfra".

Bardzo długo jednak zera nie traktowano jako liczby równouprawnionej z innymi. Zero oznaczało "nic", a "nic" nie może przecież być liczbą. Służyło ono do zapewnienia dziur i pustych miejsc, co często prowadziło do nieporozumień, pomyłek i nadużyć. Jeszcze w XV wieku zero traktowano z dużą rezerwą. Na przykład równanie

$$x^2 - 3x = 0$$

przy użyciu ówczesnej symboliki zapisywano w wersji

$$x^2 = 3x,$$

gdyż 0, jako nic nie oznaczające, nie powinno występować w równaniu. Systematycznie pomjano też rozwiązywanie zerowe. Opór związany ze stosowaniem zera został przełamany w XVI

i XVII wieku, gdy rozwinęły się techniki rachunkowe istotnie wykorzystujące system pozycyjny.

Zaliczenie zera do liczb naturalnych jest oczywiście kwestią umowy, ale ma swoje niebanalne uzasadnienie. Otóż jeśli liczby naturalne zdefiniuje się na gruncie teorii mnogości (czyli teorii zbiorów, w pewnym sensie najbardziej podstawowej), to korzystnie będzie uznać zero za liczbę naturalną; liczby naturalne określone są przy wykorzystaniu cech zbiorów skończonych, a 0 jest liczbą elementów zbioru pustego.

Warto dodać, że jedynka odgrywała wyjątkową rolę w arytmetyce starożytnych Greków. Nie uważali oni jedynki za liczbę, ale za coś w rodzaju "praliczby", czyli obiektu, który jedynie służył do tworzenia prawdziwych liczb. Według Greków pierwszą prawdziwą liczbą była dopiero dwójka.

Czym liczby 0 i 1 wyróżniają się spośród pozostałych liczb naturalnych, na czym polega ich wyjątkowość?

Odpowiedź na to pytanie wiąże się z dwoma podstawowymi działaniami arytmetycznymi - dodawaniem i mnożeniem. Działanie (w jakimś zbiorze) to przyporządkowanie dwóm dowolnym elementom z tego zbioru elementu trzeciego. Na przykład w zbiorze liczb naturalnych działaniami są: dodawanie, mnożenie, przyporządkowanie dwóm liczbom ich najmniejszej wspólnej wielokrotności. Oczywiście działania nie muszą być określone na zbiorach liczbowych, na przykład działaniem jest przyporządkowanie dwóm uczniom z jednej szkoły starszego z nich albo dwóm zbiorom ich częśći wspólnej. Liczmym przykładów dostarcza geometria, działaniem jest składanie przekształceń. Zauważmy, że odejmowanie nie jest działaniem w zbiorze liczb naturalnych! Żadnej liczby naturalnej nie otrzymamy bowiem w wyniku operacji $3-5$ (albo $7-11$). Odejmowanie jest natomiast

Diamenty Matematyki

CL Gary



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