Automorphic Functions And Fermat's Last Theorem（6）

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Abstract: In 1637 Fermat wrote: "*It is impossible to separate a cube into two cubes, or a biquadrate into two biquadrates, or in general any power higher than the second into powers of like degree: I have discovered a truly marvelous proof, which this margin is too small to contain.*" This means: $x^n + y^n = z^n (n > 2)$ has no integer solutions, all different from 0(i.e., it has only the trivial solution, where one of the integers is equal to 0). It has been called Fermat's last theorem (FLT). It suffices to prove FLT for exponent 4 and every prime exponent P. Fermat proved FLT for exponent 4. Euler proved FLT for exponent 3[8]. In this paper using automorphic functions we prove FLT for exponents $12P$ and $4P$, where P is an odd prime. The proof of FLT must be direct. But indirect proof of FLT is disbelieving.

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In 1974 Jiang found out Euler formula of the cyclotomic real numbers in the cyclotomic fields

$$\exp\left(\sum_{i=1}^{4m-1} t_i J^i\right) = \sum_{i=1}^{4m} S_i J^{i-1}, \qquad (1)$$

where J denotes a $4m$ th root of negative unity, $J^{4m} = -1$, m=1, 2, 3,…, t_i are the real numbers.

S_i is called the automorphic functions (complex trigonometric functions) of order $4m$ with $(4m-1)$ variables [5,7].

$$S_i = \frac{1}{2m}\left[(-1)^{i-1}\sum_{j=0}^{m-1} e^{B_j}\cos\left(\theta_j + \frac{(i-1)(2j+1)\pi}{4m}\right) + \sum_{j=0}^{m-1} e^{D_j}\cos\left(\phi_j - \frac{(i-1)(2j+1)\pi}{4m}\right)\right], \qquad (2)$$

where $i = 1, \ldots, 4m$;

$$B_j = \sum_{\alpha=1}^{4m-1} t_\alpha (-1)^\alpha \cos\frac{(2j+1)\alpha\pi}{4m}, \quad \theta_j = \sum_{\alpha=1}^{4m-1} t_\alpha (-1)^{1+\alpha} \sin\frac{(2j+1)\alpha\pi}{4m},$$

$$D_j = \sum_{\alpha=1}^{4m-1} t_\alpha \cos\frac{(2j+1)\alpha\pi}{4m}, \quad \phi_j = \sum_{\alpha=1}^{4m-1} t_\alpha \sin\frac{(2j+1)\alpha\pi}{4m},$$

$$2\sum_{j=0}^{m-1}(B_j + D_j) = 0. \qquad (3)$$

From (2) we have its inverse transformation[5,7]

$$e^{B_j}\cos\theta_j = S_1 + \sum_{i=1}^{4m-1} S_{1+i}(-1)^i \cos\frac{(2j+1)i\pi}{4m},$$

$$e^{B_j}\sin\theta_j = \sum_{i=1}^{4m-1} S_{1+i}(-1)^{1+i} \sin\frac{(2j+1)i\pi}{4m},$$

$$e^{D_j}\cos\phi_j = S_1 + \sum_{i=1}^{4m-1} S_{1+i} \cos\frac{(2j+1)i\pi}{4m},$$

$$e^{D_j}\sin\phi_j=\sum_{i=1}^{4m-1} S_{1+i}\sin\frac{(2j+1)i\pi}{4m}. \quad (4)$$

(3) and (4) have the same form.

From (3) we have

$$\exp\left[2\sum_{j=0}^{m-1}(B_j+D_j)\right]=1. \quad (5)$$

From (4) we have

$$\exp\left[2\sum_{j=0}^{m-1}(B_j+D_j)\right]=\begin{vmatrix} S_1 & -S_{4m} & \cdots & -S_2 \\ S_2 & S_1 & \cdots & -S_3 \\ \cdots & \cdots & \cdots & \cdots \\ S_{4m} & S_{4m-1} & \cdots & S_1 \end{vmatrix}=\begin{vmatrix} S_1 & (S_1)_1 & \cdots & (S_1)_{4m-1} \\ S_2 & (S_2)_1 & \cdots & (S_2)_{4m-1} \\ \cdots & \cdots & \cdots & \cdots \\ S_{4m} & (S_{4m})_1 & \cdots & (S_{4m})_{4m-1} \end{vmatrix} \quad (6)$$

where

$$(S_i)_j=\frac{\partial S_i}{\partial t_j}\,[7]$$

From (5) and (6) we have circulant determinant

$$\exp\left[2\sum_{j=0}^{m-1}(B_j+D_j)\right]=\begin{vmatrix} S_1 & -S_{4m} & \cdots & -S_2 \\ S_2 & S_1 & \cdots & -S_3 \\ \cdots & \cdots & \cdots & \cdots \\ S_{4m} & S_{4m-1} & \cdots & S_1 \end{vmatrix}=1 \quad (7)$$

If $S_i\neq 0$, where $i=1,2,\ldots,4m$, then (7) has infinitely many rational solutions.

Assume $S_1\neq 0, S_2\neq 0,$ and $S_i=0$, where $i=3,\ldots,4m$. $S_i=0$ are $(4m-2)$ indeterminate equations with $(4m-1)$ variables. From (4) we have

$$e^{2B_j}=S_1^2+S_2^2-2S_1S_2\cos\frac{(2j+1)\pi}{4m},\ e^{2D_j}=S_1^2+S_2^2+2S_1S_2\cos\frac{(2j+1)\pi}{4m}, \quad (8)$$

Example. Let $m=15$. From (3) and (8) we have Fermat's equations

$$\exp[2\sum_{j=0}^{14}(B_j+D_j)]=S_1^{60}+S_2^{60}=(S_1^{20})^3+(S_2^{20})^3=1. \quad (9)$$

From (3) we have

$$\exp[2\sum_{j=0}^{4}(B_{3j+1}+D_{3j+1})]=[\exp(-t_{20}+t_{40})]^{20}. \quad (10)$$

From (8) we have

$$\exp[2\sum_{j=0}^{4}(B_{3j+1}+D_{3j+1})]=S_1^{20}+S_2^{20} \quad (11)$$

From (10) and (11) we have Fermat's equation

$$\exp[2\sum_{j=0}^{4}(B_{3j+1}+D_{3j+1})]=S_1^{20}+S_2^{20}=[\exp(-t_{20}+t_{40})]^{20} \quad (12)$$

Euler prove that (9) has no rational solutions for exponent 3[8]. Therefore we prove that (12) has no rational solutions for exponent 20.

Theorem. Let $m=3P$, where P is an odd prime. From (3) and (8) we have Fermat's equation.

$$\exp[2\sum_{j=0}^{3P-1}(B_j+D_j)]=S_1^{12P}+S_2^{12P}=(S_1^{4P})^3+(S_2^{4P})^3=1 \quad (13)$$

From (3) we have

$$\exp[2\sum_{j=0}^{3P-1}(B_{3j+1}+D_{3j+1})]=[\exp(-t_{4P}+t_{8P})]^{4P}. \quad (14)$$

From (8) we have

$$\exp[2\sum_{j=0}^{P-1}(B_{3j+1}+D_{3j+1})]=S_1^{4P}+S_2^{4P}. \quad (15)$$

From (14) and (15) we have Fermat's equation

$$\exp[2\sum_{j=0}^{P-1}(B_{3j+1}+D_{3j+1})]=S_1^{4P}+S_2^{4P}=[\exp(-t_{4P}+t_{8P})]^{4P} \quad (16)$$

Euler prove that (13) has no rational solutions for exponent 3 [8]. Therefore we prove that (16) has no rational solutions for exponent $4P$ [5,7].

Remark. It suffices to prove FLT for exponent 4. Let $n=4P$, where P is an odd prime. We have the Fermat's equation for exponent $4P$ and the Fermat's equation for exponent P [5,7]. This is the proof that Fermat thought to have had. In complex hyperbolic functions let exponent n be $n=\Pi P$, $n=2\Pi P$ and $n=4\Pi P$. Every factor of exponent n has Fermat's equation [1-7]. In complex trigonometric functions let exponent n be $n=\Pi P$, $n=2\Pi P$ and $n=4\Pi P$. Every factor of exponent n has Fermat's equation [1-7]. Using modular elliptic curves Wiles and Taylor prove FLT [9,10]. This is not the proof that Fermat thought to have had.

The classical theory of automorphic functions, created by Klein and Poincarè, was concerned with the study of analytic functions in the unit circle that are invariant under a discrete group of transformation. Automorphic function are the generalization of trigonometric, hyperbolic, elliptic, and certain other functions of elementary analysis. The automorphic functions (complex trigonometric functions and complex hyperbolic functions) have a wide application in mathematics and physics.

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