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 the complex trigonometric 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.

In 1974 Jiang found out Euler formula

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

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

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

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]

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

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

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

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

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

From (3) we have

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

From (4) we have

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

where

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

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

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

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 $i = 3, ..., 4m$. $S_i = 0$ are $(4m-2)$ indeterminate equations with $(4m-1)$ variables. From (4) we have

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

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

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

From (3) we have

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

From (8) we have

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

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

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

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.

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

From (3) we have

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

From (8) we have

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

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

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

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].

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