The New Prime theorem（17）

$$P_n = 2P_1P_2\cdots P_{n-1} \pm 1$$

Chun-Xuan Jiang

P. O. Box 3924, Beijing 100854, P. R. China
jiangchunxuan@vip.sohu.com

Abstract: Using Jiang function we prove that such that $P_n = 2P_1P_2\cdots P_{n-1} \pm 1$ has infinitely many prime solutions.

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Theorem. The prime equation

$$P_n = 2P_1P_2\cdots P_{n-1} + 1 \qquad (1)$$

has infinitely many prime solutions.

Proof. We have Jiang function[1]

$$J_n(\omega) = \prod_P [(P-1)^{n-1} - \chi(P)], \qquad (2)$$

where $\omega = \prod_P P$, $\chi(P)$ is the number of solutions of congruence

$$2q_1q_2\cdots q_{n-1} + 1 \equiv 0 \pmod P, \quad q_i = 1,\cdots,P-1, i = 1,\cdots,n-1, \qquad (3)$$

From (3) we have

$$\chi(P) = (P-1)^{n-2} \qquad (4)$$

Substituting (4) into (2) we have

$$J_n(\omega) = \prod_{3\le P}[(P-1)^{n-2}(P-2)] \ne 0. \qquad (5)$$

We prove that (1) has infinitely many prime solutions. $J_n(\omega) \subset \phi^{n-1}(\omega)$.
We have the best asymptotic formula [1]

$$\pi_2(N,n) = \left|\{P_1,\cdots,P_{n-1} \le N : P_n = prime\}\right| \sim \frac{J_n(\omega)\omega}{(n-1)!\phi^n(\omega)}\frac{N^{n-1}}{\log^n N}. \qquad (6)$$

Example 1. Let $n = 2$. From (1) we have

$$P_2 = 2P_1 + 1 \qquad (7)$$

From (5) we have

$$J_2(\omega) = \prod_{3\le P}(P-2) \ne 0 \qquad (8)$$

Example 2. Let $n = 3$. From (1) we have

$$P_3 = 2P_1P_2 + 1. \qquad (9)$$

From (5) we have

$$J_3(\omega) = \prod_{3\le P}[(P-1)(P-2)] \ne 0. \qquad (10)$$

In the same way we are able to prove that

$$P_m = 2P_1P_2\cdots P_{n-1} - 1 \qquad (11)$$

has infinitely many prime solutions.

Note. The prime numbers theory is to count the Jiang function $J_{n+1}(\omega)$ and Jiang singular series $\sigma(J) = \frac{J_2(\omega)\omega^{k-1}}{\phi^k(\omega)} = \prod_P \left(1 - \frac{1+\chi(P)}{P}\right)(1-\frac{1}{P})^{-k}$ [1], which can count the number of prime number. The prime number is not random. But Hardy singular series $\sigma(H) = \prod_P \left(1 - \frac{\nu(P)}{P}\right)(1-\frac{1}{P})^{-k}$ is false [2-5], which cannot count the number of prime numbers.

Author in US address:
Chun-Xuan Jiang
Institute for Basic Research Palm Harbor, FL 34682, U.S.A.
Jiangchunxuan@vip.sohu.com

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