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Odd Triperfect Numbers

By Masao Kishore*

Abstract. We prove that an odd triperfect number has at least ten distinct prime factors.

1. A positive number N is called a triperfect number if $\sigma(N) = 3N$, where $\sigma(N)$ is the sum of the positive divisors of N. Six even triperfect numbers are known:

$$\begin{aligned}&2^{14} \cdot 5 \cdot 7 \cdot 19 \cdot 31 \cdot 151,\\ &2^{13} \cdot 3 \cdot 11 \cdot 43 \cdot 127,\\ &2^{9} \cdot 3 \cdot 11 \cdot 31,\\ &2^{8} \cdot 5 \cdot 7 \cdot 19 \cdot 37 \cdot 73,\\ &2^{5} \cdot 3 \cdot 7,\\ &2^{3} \cdot 3 \cdot 5.\end{aligned}$$

However, the existence of an odd triperfect (OT) number is an open question. McDaniel [1] and Cohen [2] proved that an OT number has at least nine distinct prime factors, and Beck and Najar [3] showed that it exceeds 10^{50}.

In this paper using the technique of [4], we prove

THEOREM. *If N is OT, N has at least ten distinct prime factors.*

2. Throughout this paper we let

$$N = \prod_{i=1}^{r} p_i^{a_i},$$

where p_i's are odd primes, $p_1 < \cdots < p_r$ and a_i's are positive integers.

The following lemmas are easy to prove:

LEMMA 1. *If N is OT,*

(1) $\qquad$ *a_i's are even for $1 \leqslant i \leqslant r$.*

LEMMA 2. *If N is OT and q is a prime factor of $\sigma(p_i^{a_i})$ for some i, then $q = 3$ or $q = p_j$ for some j, $1 \leqslant j \leqslant r$.*

LEMMA 3. *If N is OT and $r = 9$, $p_8 < 80$.*

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As in [4] we define

$$S(N) = \sigma(N)/N,$$
$$a(p) = \mathrm{Min}\{a \mid a \text{ is even and } p^{a+1} > 10^{11}\},$$
$$b_i = \mathrm{Min}\{a_i, a(p_i)\},$$
$$M = \prod_{i=1}^{r} p_i^{b_i}.$$

LEMMA 4. *If N is OT, then*

$$\log 3 - r \cdot 10^{-11} < \log S(M) \leqslant \log 3. \tag{2}$$

Proof. Since $M \mid N$, $S(M) \leqslant S(N) = 3$ and so $\log S(M) \leqslant \log 3$. In [4] we proved that if $a > a(p)$, then

$$0 < \log S(p^a) - \log S(p^{a(p)}) < 10^{-11}.$$

Hence

$$0 < \log S(N) - \log S(M) < r \cdot 10^{-11},$$

and we have

$$\log 3 - r \cdot 10^{-11} = \log S(N) - r \cdot 10^{-11} < \log S(M).$$

Q.E.D.

COROLLARY. *If N is OT, $L = M/p_r^{b_r}$ and if $p_r > 3500$, then*

$$\log 3 - r \cdot 10^{-11} - \log S(3499^2) < \log S(L) < \log 3. \tag{3}$$

Proof of Theorem. We used a computer (PDP 11 at the University of Toledo) to find

$$M = \prod_{i=1}^{9} p_i^{a_i}$$

satisfying (1), $a_i \leqslant a(p_i)$ for $1 \leqslant i \leqslant 9$, (2) with $r = 9$, and $p_9 < 3500$. There were 71 such M's; however, all of them had a factor $p_i^{a_i}$ such that $a_i < a(p_i)$, $\sigma(p_i^{a_i})$ had a prime factor $q > 3$, and $q \neq p_j$, $1 \leqslant j \leqslant 9$.

Next we tried to find

$$L = \prod_{i=1}^{8} p_i^{a_i}$$

satisfying (1), $a_i \leqslant a(p_i)$ for $1 \leqslant i \leqslant 8$, and (3) with $r = 9$. There were 12689 such L's; however, 12473 of them had a factor $p_i^{a_i}$ such that $a_i < a(p_i)$, $\sigma(p_i^{a_i})$ had a prime factor $q > 3$, $q \neq p_j$ for $1 \leqslant j \leqslant 8$, and

$$\log S(L) + \log S(q^2) > \log 3.$$

The remaining 216 of them had the following properties: there exist two consecutive primes u and v such that $3500 < u < v$,

$$\log S(L) + \log S(u^2) > \log 3, \quad \text{and}$$
$$\log S(L) + \log v/(v-1) < \log 3 - 9 \cdot 10^{-11}.$$

These three cases show that if N is an odd integer with $r = 9$, then N cannot be OT. Q.E.D.

The computer time was over five hours.

Department of Mathematics
East Carolina University
Greenville, North Carolina 27834

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