Of course, if we allow the Martians to refuel, the vehicle could have only two stages* and the gross weight would be only $\left(\frac{100}{9}\right)^2$ = 123 times the payload, i.e., 250,000 pounds. This would require bringing electrolytic and refrigerating equipment and sitting at the South Pole long enough to extract fuel for the hourney home, since they have not asked us for supplies. Our oceans (electrolysis to make H_2) would be obvious to Martian telescopes and they might conceivably follow such a plan, particularly if they came here without foreknowledge that Earth has a civilization.

Requirements for a trip from a planet attached to some star other than the Sun can be calculated in a similar manner. Here the energy (or velocity) required has more parts: (a) escape from the planet (b) escape from the star (c) enough velocity to traverse a few light years of space in reasonable time (d) deceleration toward the Sun (e) deceleration toward the Earth. The nearest "eligible" star is an object called Wolf 359 (see reference 4, p 52), at a distance of 8.0 light years. It is small, having an absolute magnitude of 16.6 and is typical of "red dwarfs" which make up more than half of the eligible populations. By comparison with similar stars of known mass, this star is estimated to have a mass roughly 0.03 as great as the sun. Since the star has a low luminosity (being much cooler and smaller than the Sun) a habitable planet would need to be in a small orbit for warmth.

T H I S P A G E I S U N C L A S S I F I E D

Of the changes of energy required as listed in the preceding paragraph, item (c), velocity to traverse intervening space, is so large as to make the others completely neglibible. If the visitors were long lived and could "hibernate" for 80 years both coming and going, then 1/10 the speed of light would be required, i.e., the enormous velocity of 18,000 miles per second. This is completely beyond the reach of any predided level of rocket propulsion.

If a race were far enough advanced to make really efficient use of nuclear energy, then a large part of the mass of the nuclear material might be converted into jet energy. We have no idea how to do this, in fact reference 6 indicates that the materials required to withstand the temperatures, etc., may be fundamentally unattainable. Let us start from a jet-propellant-to-gross-weight ratio of .75. If the total amount of expended material (nuclear plus propellent) can be 0.85 of the gross weight, then the nuclear material expended can be 0.10 of the gross. Using an efficiency of 0.5 for converting nuclear energy to jet energy and neglecting relativistic mass corrections, then a rocket velocity of half the velocity of light could be attained. This would mean a transit time of 16 years each way from the star Wolf 359, or longer times from other eligible stars. To try to go much faster would mean spending much energy on relativistic change in mass and therefore operating at lowered efficiency.

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* Actually three stages. On the trip to Earth, the first stage would be filled with fuel, the second stage would contain partial fuel, the third would be empty. The first stage would be thrown away during flight. On the trip back to Mars, the second and third stages would be filled with fuel. The gross weight of the initial vehicle would be of the order of magnitude of a two-stage rocket.