

<i>Program/Phase</i>	<i>Number of Messages</i>	<i>Bodies per Message</i>
Manager/workers		
Get task	$2 * (\text{numTasks} + \text{PR})$	2
Exchange forces	$\text{PR} * (\text{PR} - 1)$	n
Exchange bodies	$\text{PR} * (\text{PR} - 1)$	$2 * n$
Heartbeat		
Exchange bodies	$\text{PR} * (\text{PR} - 1) / 2$	$2 * n$
Exchange forces	$\text{PR} * (\text{PR} - 1) / 2$	n
Pipeline		
Circulate bodies	$\text{PR} * \text{PR}$	$3 * n * \text{PR}$

**Figure Table 11.1** Comparison of message-passing programs for  $n$ -body problem.

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