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*The regularity of almost periodic modulo solution and applications.*

We consider the  $L_x^2$  solution  $u$  to mass critical NLS  $iu_t + \Delta u = \pm|u|^{\frac{4}{d}}u$ . We proved that in dimensions  $d \geq 4$ , if the solution is spherically symmetric and is *almost periodic modulo scaling*, then it must belong to  $H_x^{1+\epsilon}$  for some  $\epsilon > 0$ . Moreover, the kinetic energy of the solution is localized uniformly in time. One important application of the theorem is a simplified proof of the scattering conjecture for mass critical NLS without reducing to three enemies. As another important application, we establish a Liouville type result for  $L_x^2$  initial data with ground state mass. We prove that if a radial  $L_x^2$  solution to focusing mass critical problem has the ground state mass and does not scatter in both time directions, then it must be global and coincide with the solitary wave up to symmetries. Here the ground state is the unique, positive, radial solution to elliptic equation  $\Delta Q - Q + Q^{1+\frac{4}{d}} = 0$ . This is the first rigidity type result in scale invariant space  $L_x^2$ . (Received September 11, 2009)