Formation of Binary and Millisecond Pulsars: Puzzles and Possible Solutions

Xiang-Dong Li and Yong Shao
Department of Astronomy
Nanjing University

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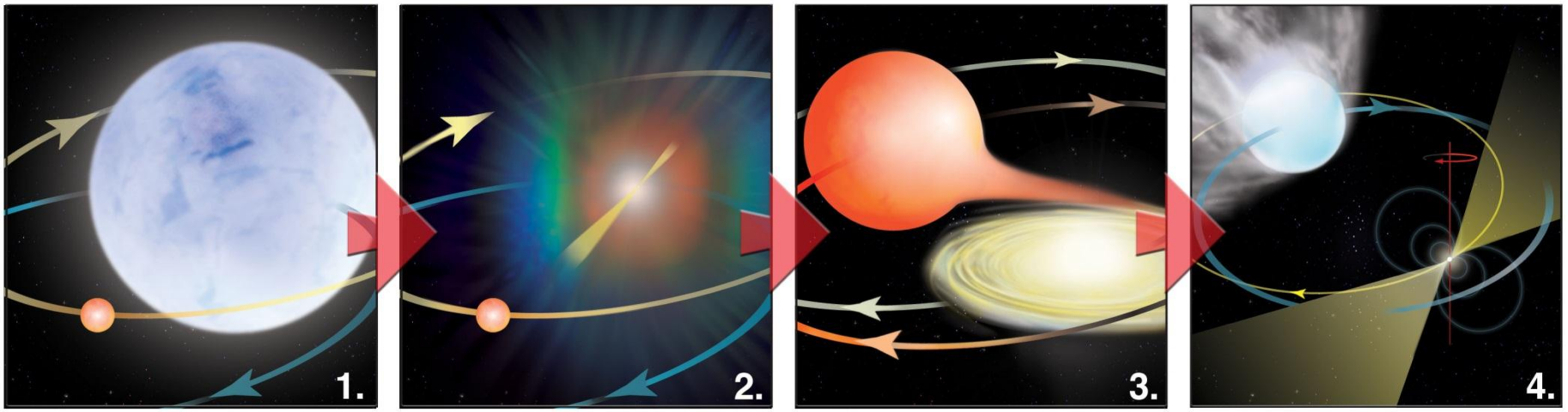
Millisecond pulsars (MSPs) are believed to have been recycled from low-mass X-ray binaries

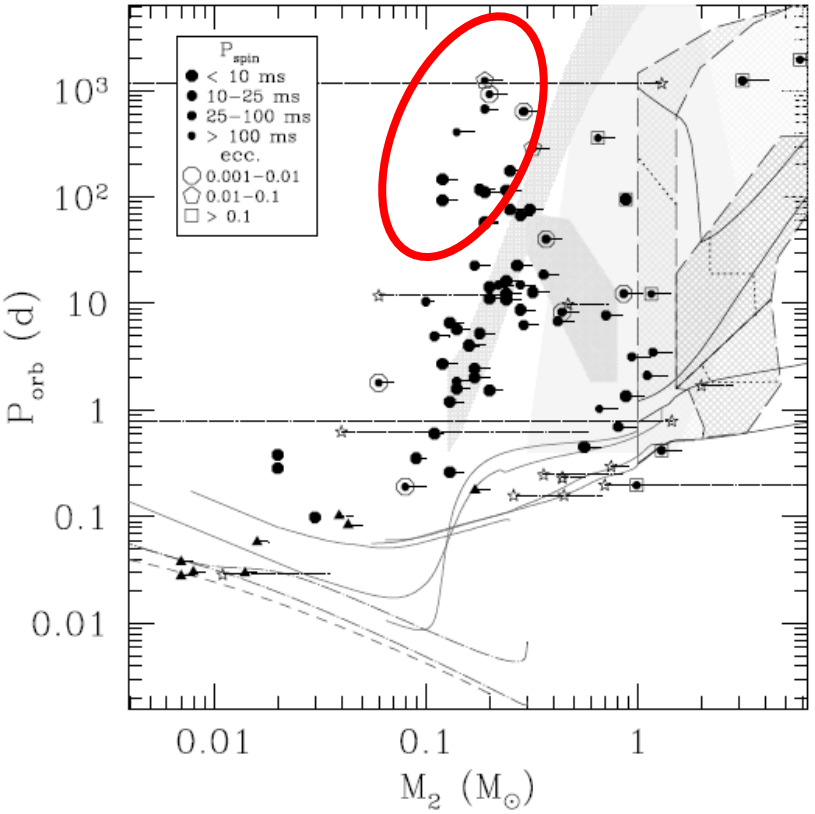
Credit: NRAO



Progenitor binary SN → radio pulsar LMXB ms pulsar

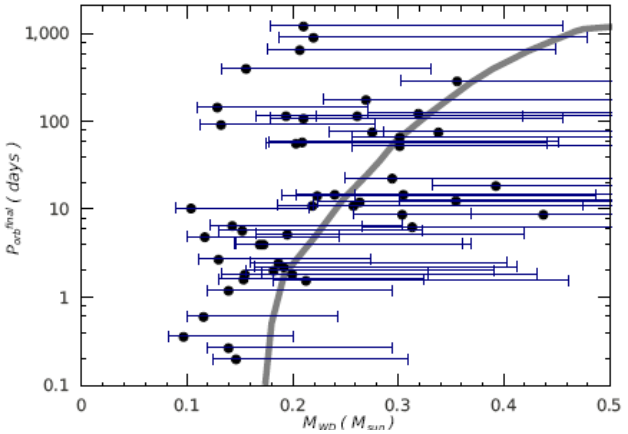
Puzzle 1: How to Form MSPs in wide orbits?

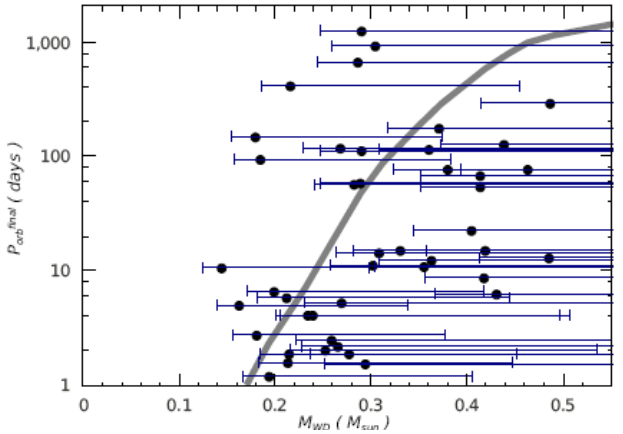
- Difficult for the NS to accrete enough mass
- The white dwarf companions seem to be less massive than predicted

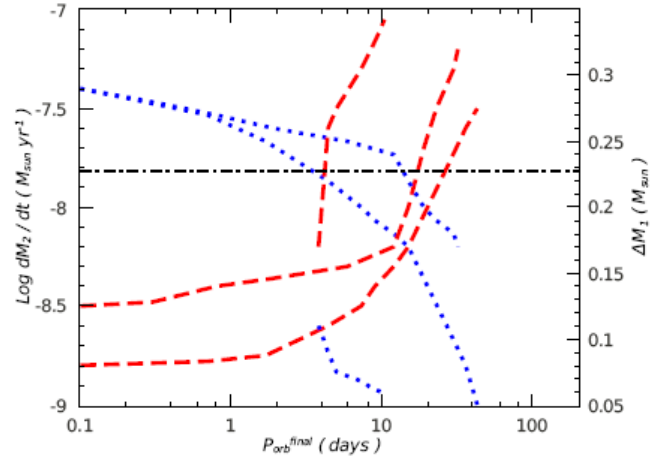


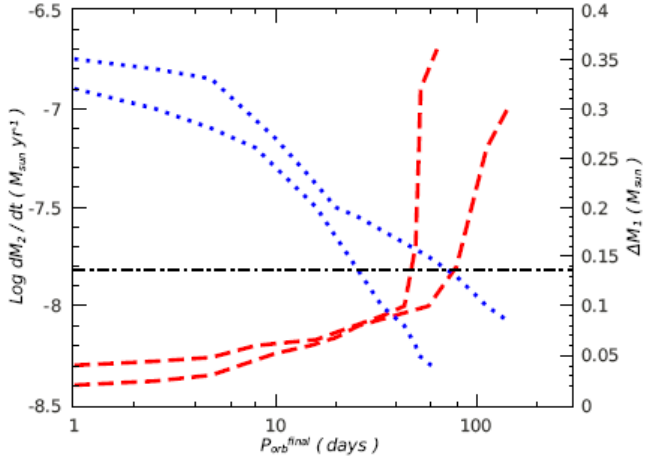
Deloye (2008)

One possible solution is that the NS were born massive







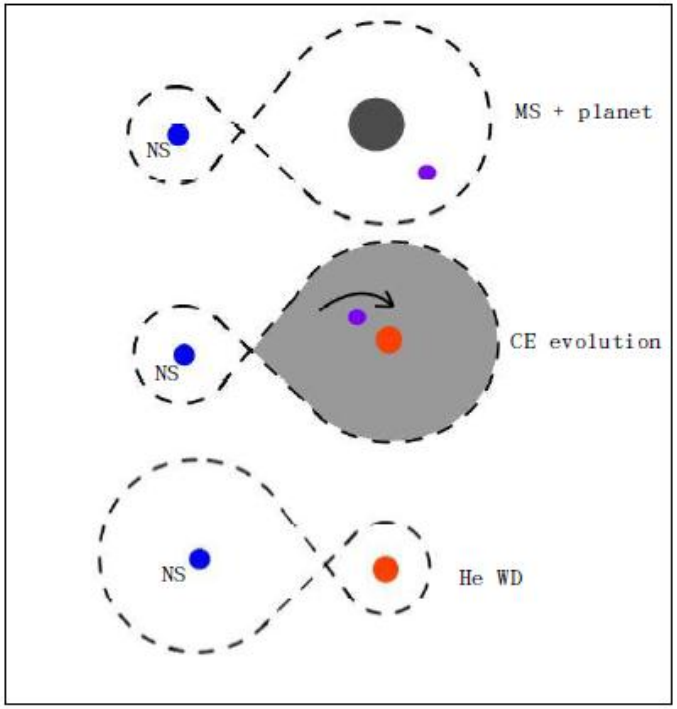


$M_{NS,f}$ =1.2 $M_\odot$

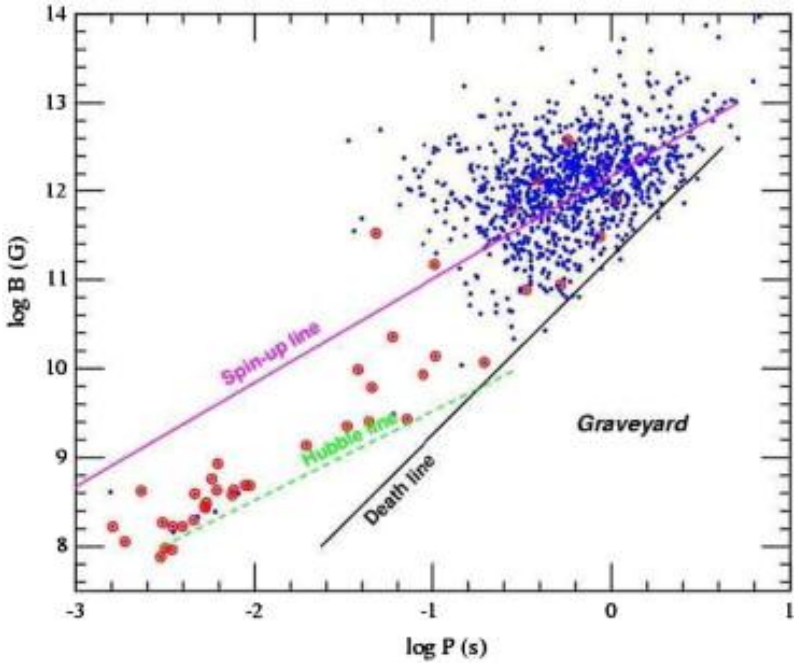
$M_{NS,f}$ = 2.0 $M_\odot$

Another is with the help of planets

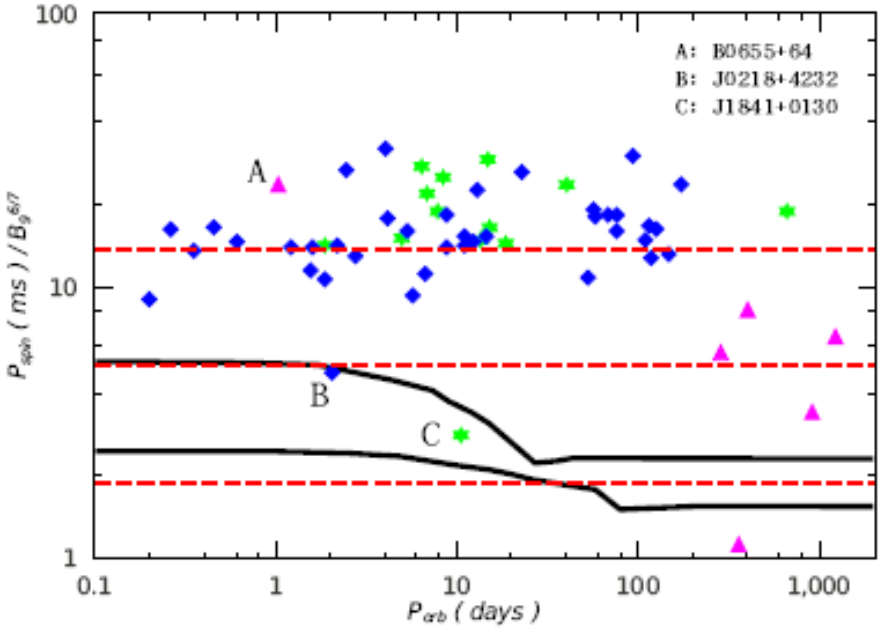
- The companion star in the progenitor LMXBs may have possessed planet(s)
- When the star evolved, it may became big enough to capture its planet(s)
- The planet(s) spiraled into the envelope of the giant, and expelled the envelope, leaving a light remnant



Puzzle 2: The rebirth periods of MSPs appear to be much longer than the equilibrium periods



Srinivasan 2010



Shao & Li 2012

Possible solutions include

- Gravitational radiation Seems not favored
- Disk-field interaction Strong spin-down torque(s) required
- Slow shut-off of mass transfer

  May increase P_s by a factor of a few
- long-term spin equilibrium with varying mass accretion rate due to irradiation of the donors and unstable accretion disks