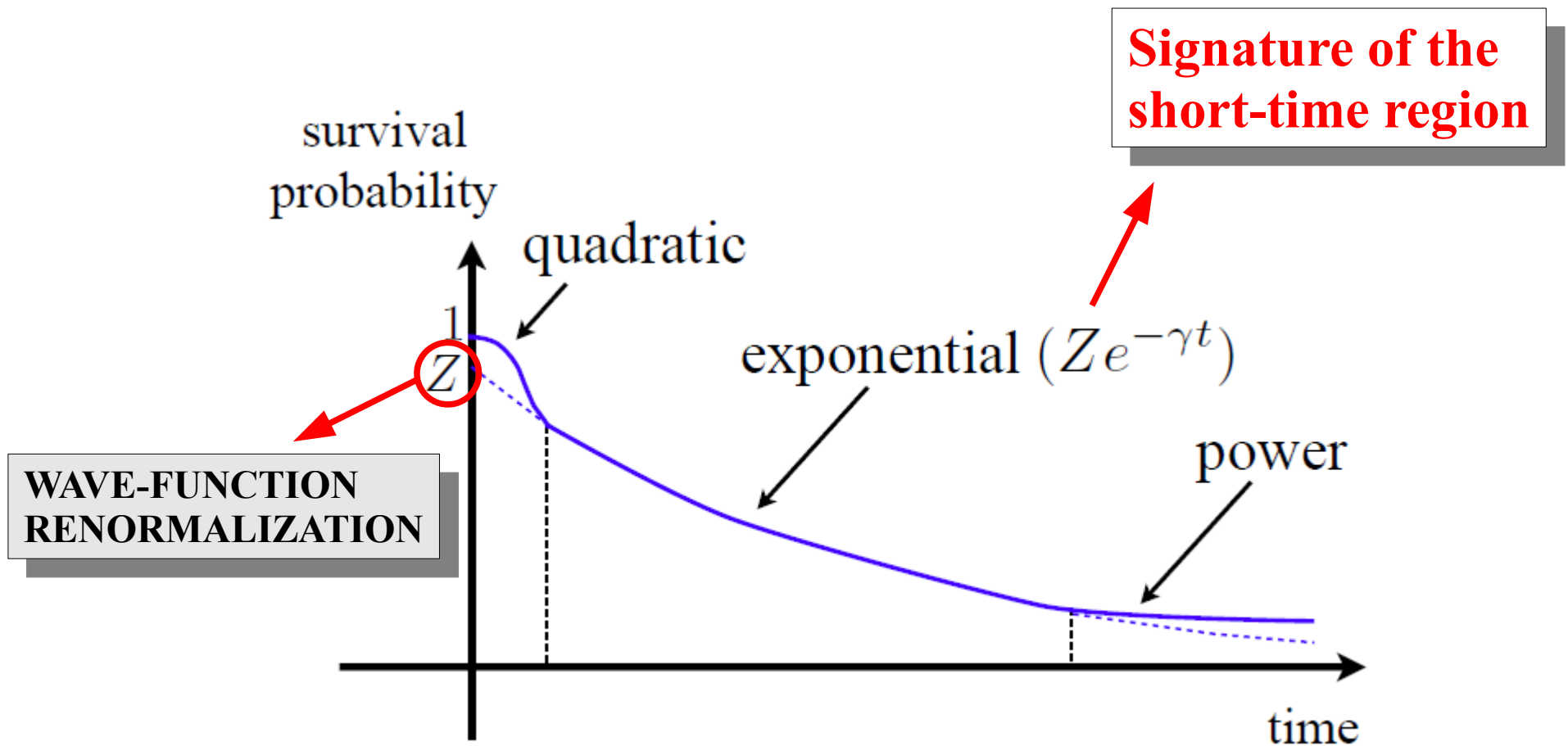# Quantum simulation of decay with Bose-Einstein condensates

Francesco Pepe

*Bari Xmas Theory Workshop 2013*

# Decay of an unstable state

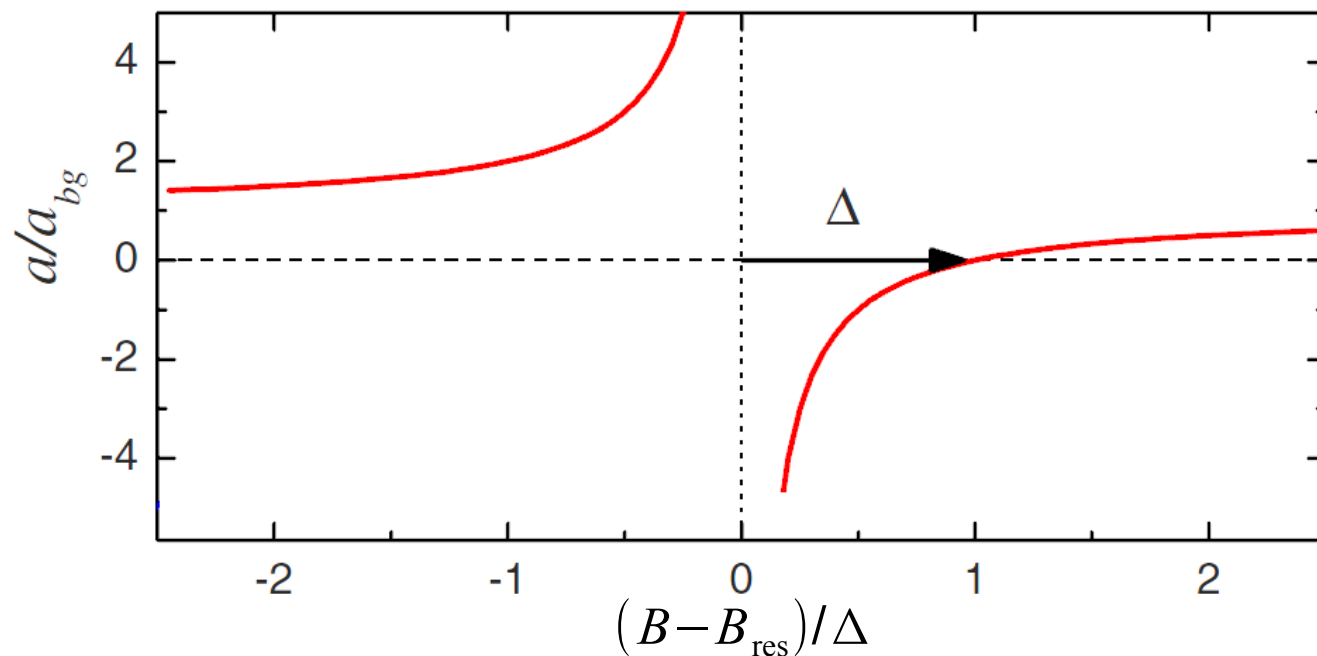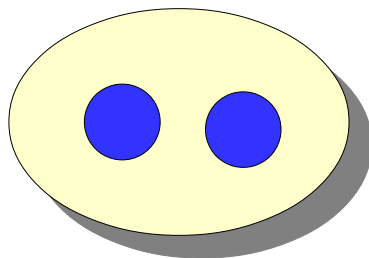$$P(t) \sim \exp(-\gamma t)$$ only at **intermediate** times



survival probability

quadratic

Signature of the short-time region

1

Z

exponential $(Ze^{-\gamma t})$

power

WAVE-FUNCTION RENORMALIZATION

time

# Feshbach molecules

**Feshbach resonance** $\longrightarrow$ divergence in the *s*-wave scattering length
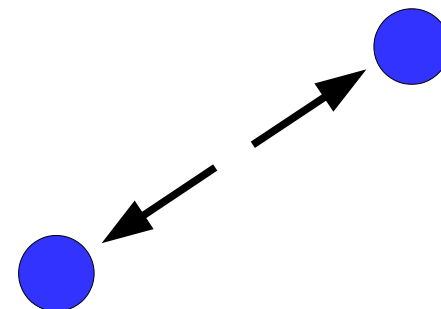
$$a(B)=a_{bg}\left(1-\frac{\Delta}{B-B_{res}}\right)$$



Stable for $B < B_{res}$

**Unstable** for $B > B_{res}$

**MOLECULES**

C. Chin, R. Grimm, P. Julienne, and E. Tiesinga, Rev. Mod. Phys. **82**, 1225 (2010)

# Feshbach molecules



*WEAKLY BOUND STATE*
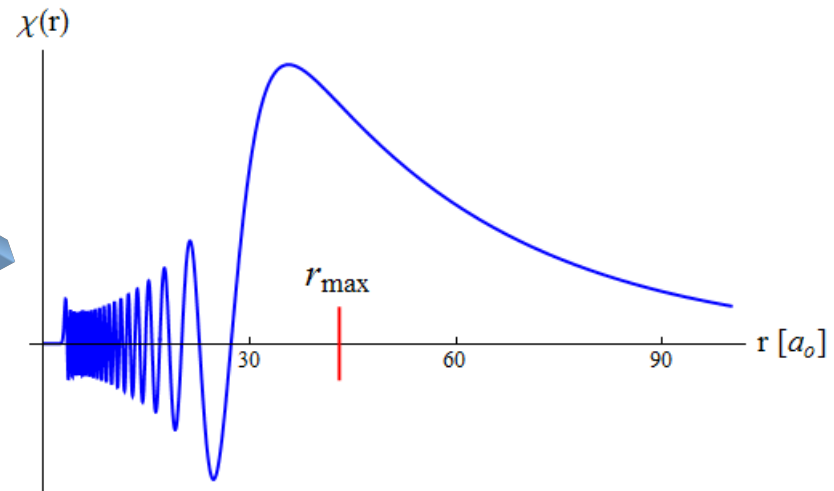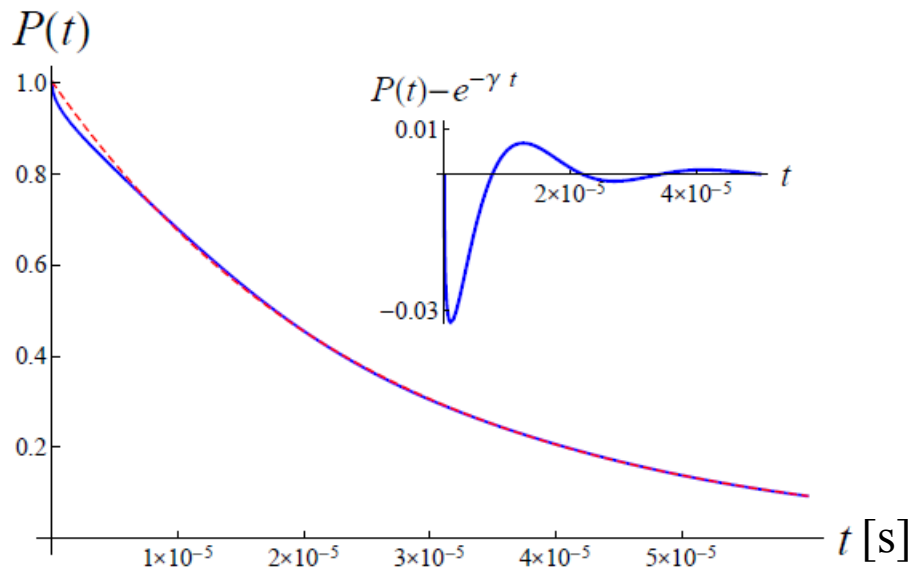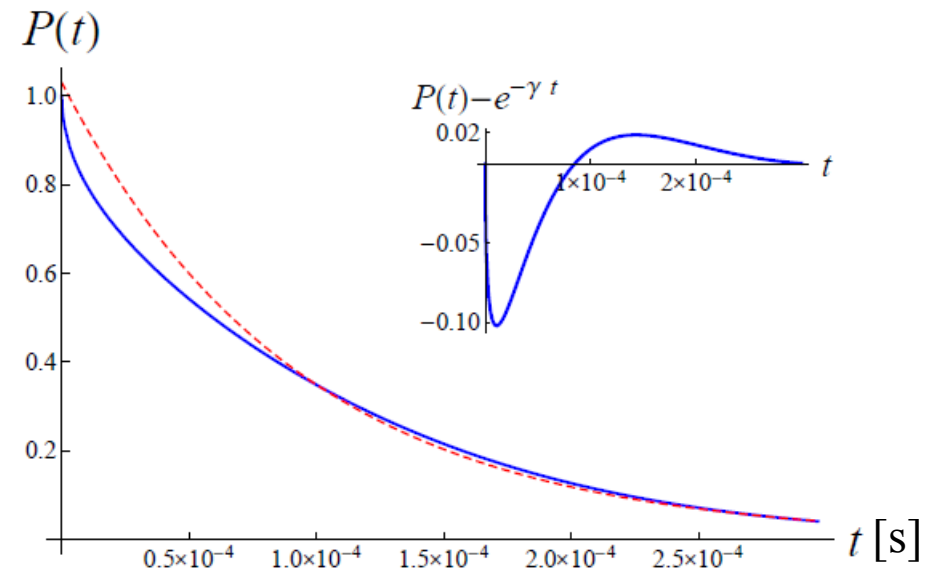
## WHY STUDIYNG DECAY OF FESHBACH MOLECULES?

• Easy tunability of the parameters (external magnetic field)

• Molecules are bosons! → At low temperature, condensation in the same single-particle state occurs

• Large decay times

• **Different *observable* decay regimes**

# Time evolution: "unusual" decay
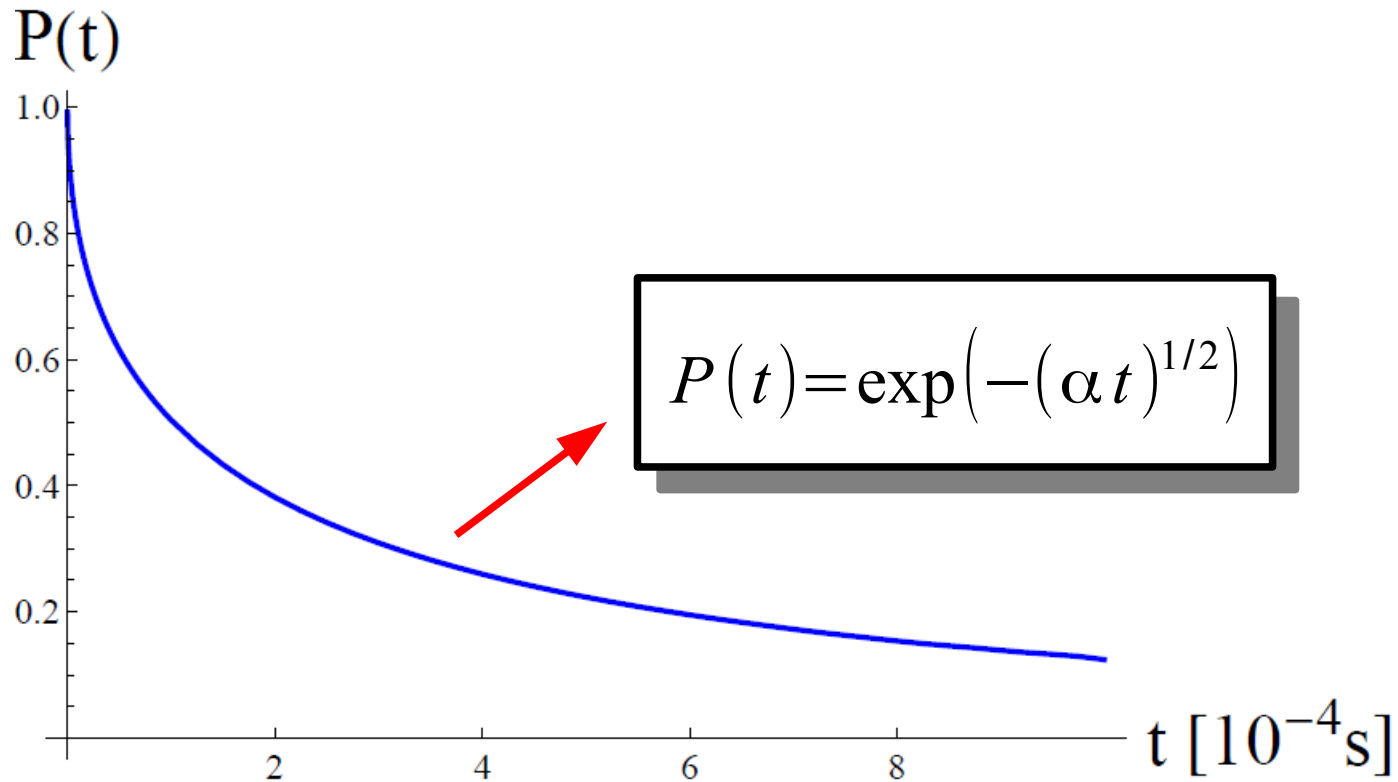
$$^6\text{Li}, \ B_{\text{res}} = 543.25 \text{ G}$$



$$B - B_{\text{res}} \approx 10^{-2} \text{ G}$$



$$B - B_{\text{res}} \approx 10^{-3} \text{ G}$$

*Deviations from the exponential becomes larger and more extended in time as the system approaches the resonance*

# Stretched exponential regime



$$P(t) = \exp\left(-(\alpha t)^{1/2}\right)$$

$B - B_{res} = 2 \cdot 10^{-5}$ G

Observed also in RELAXATION DYNAMICS OF GLASS-LIKE SYSTEMS

[see e.g. L. Berthier and G. Biroli, Rev. Mod. Phys **83**, 587 (2011)]