Superconducting nanorings that operate as Brownian ratchets

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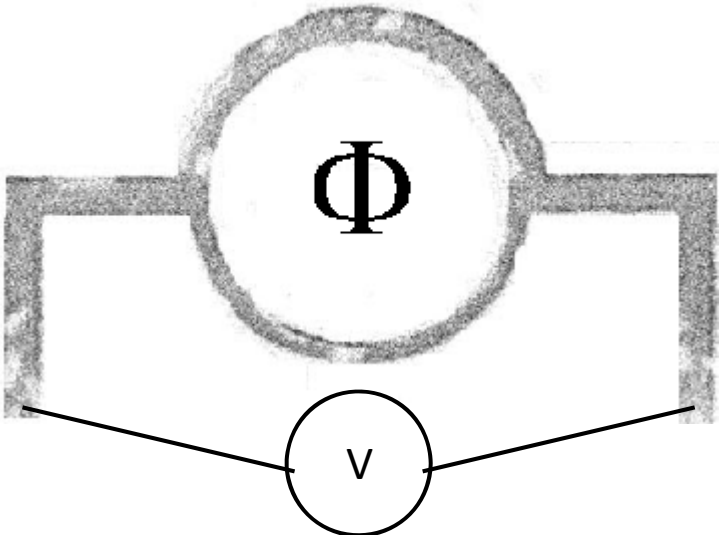
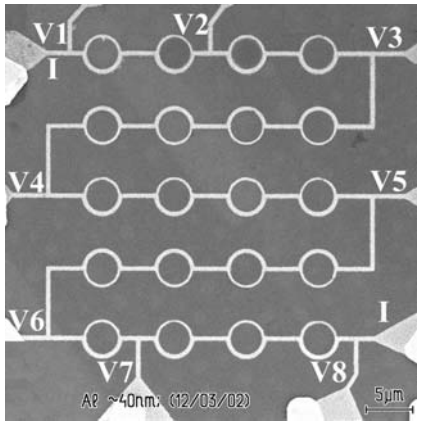
Steps of this talk

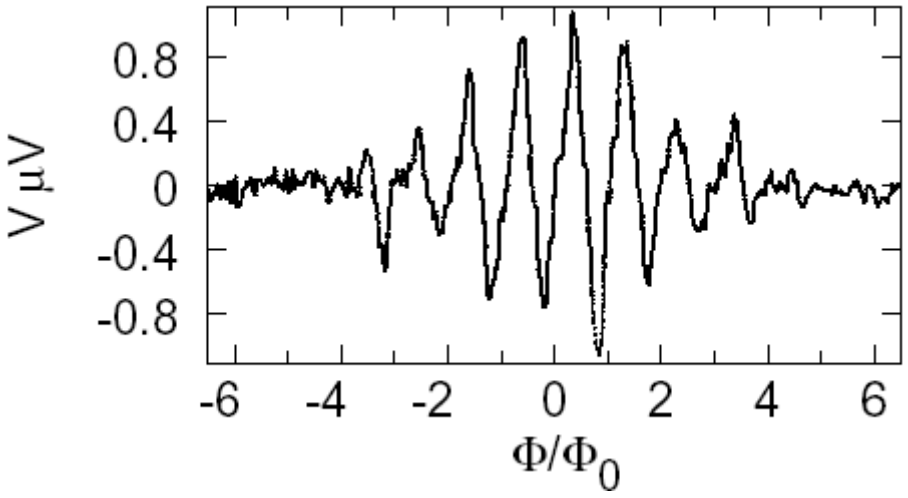
- Background
  - Motivation
  - What is a Brownian motor?
- System we consider
  - Description
  - Evolution equations
  - Why this system is a Brownian motor
  - Is it?

The Chernogolovka experiments (1998-2011)

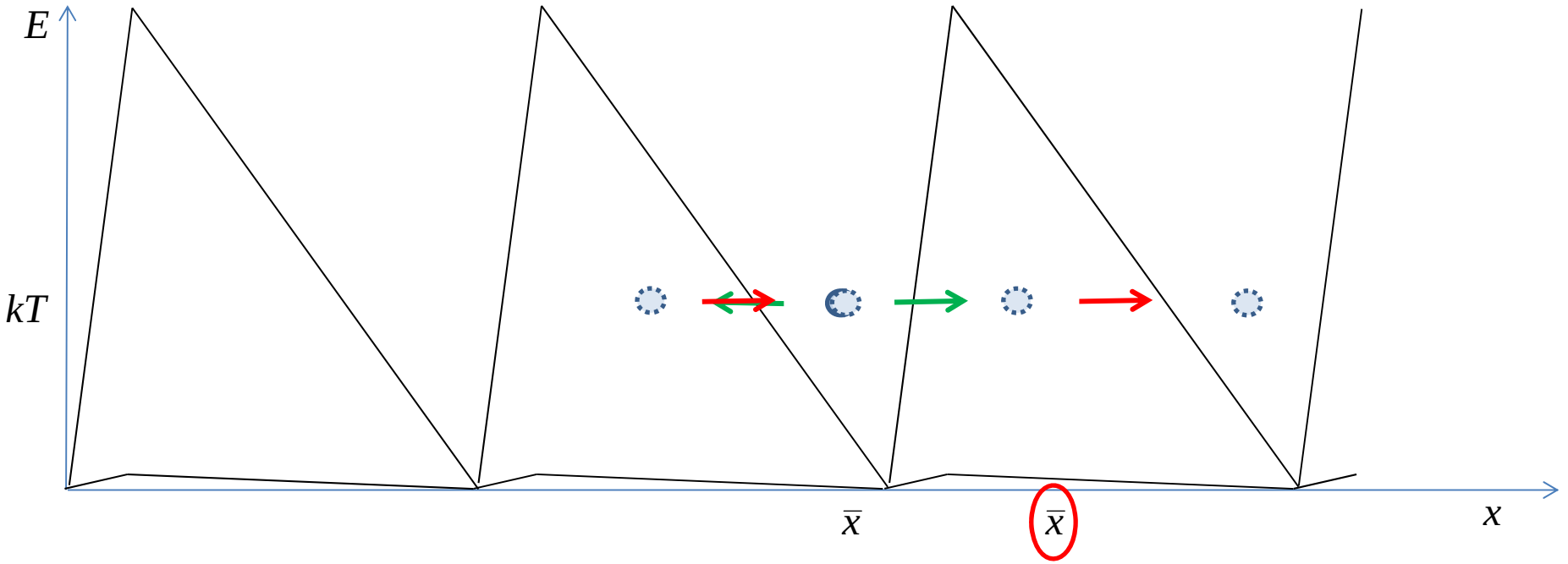




Close to Tc

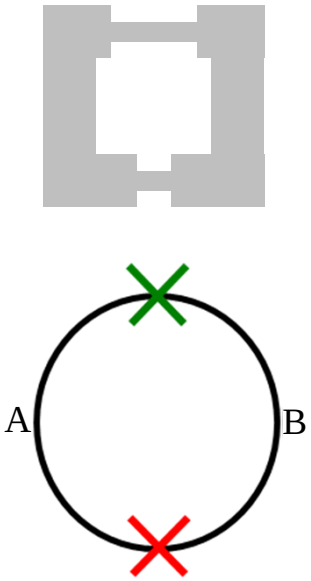


Brownian motor



Our system

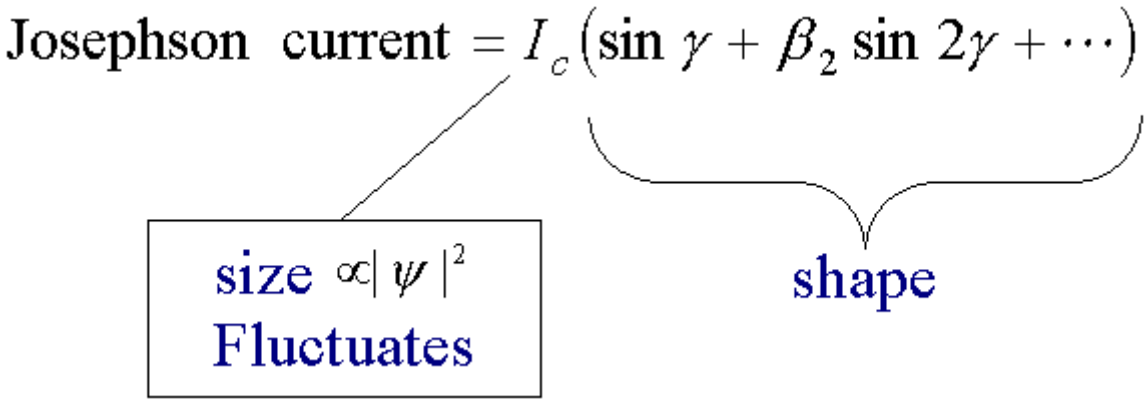
Superconducting loop with two unequal weak links

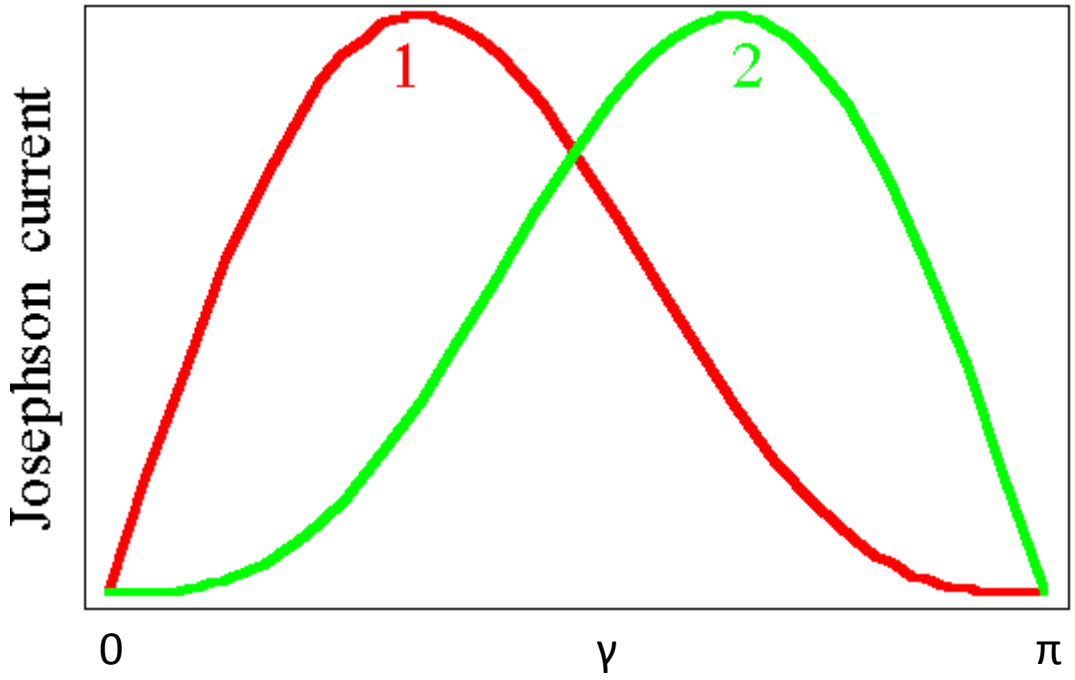


The voltage across a weak link can be evaluated using the Josephson equation

$$V_i = \frac{d\gamma_i}{dt}$$

current through a weak link= superconducting+ohmic+capacitive+thermal fluctuations





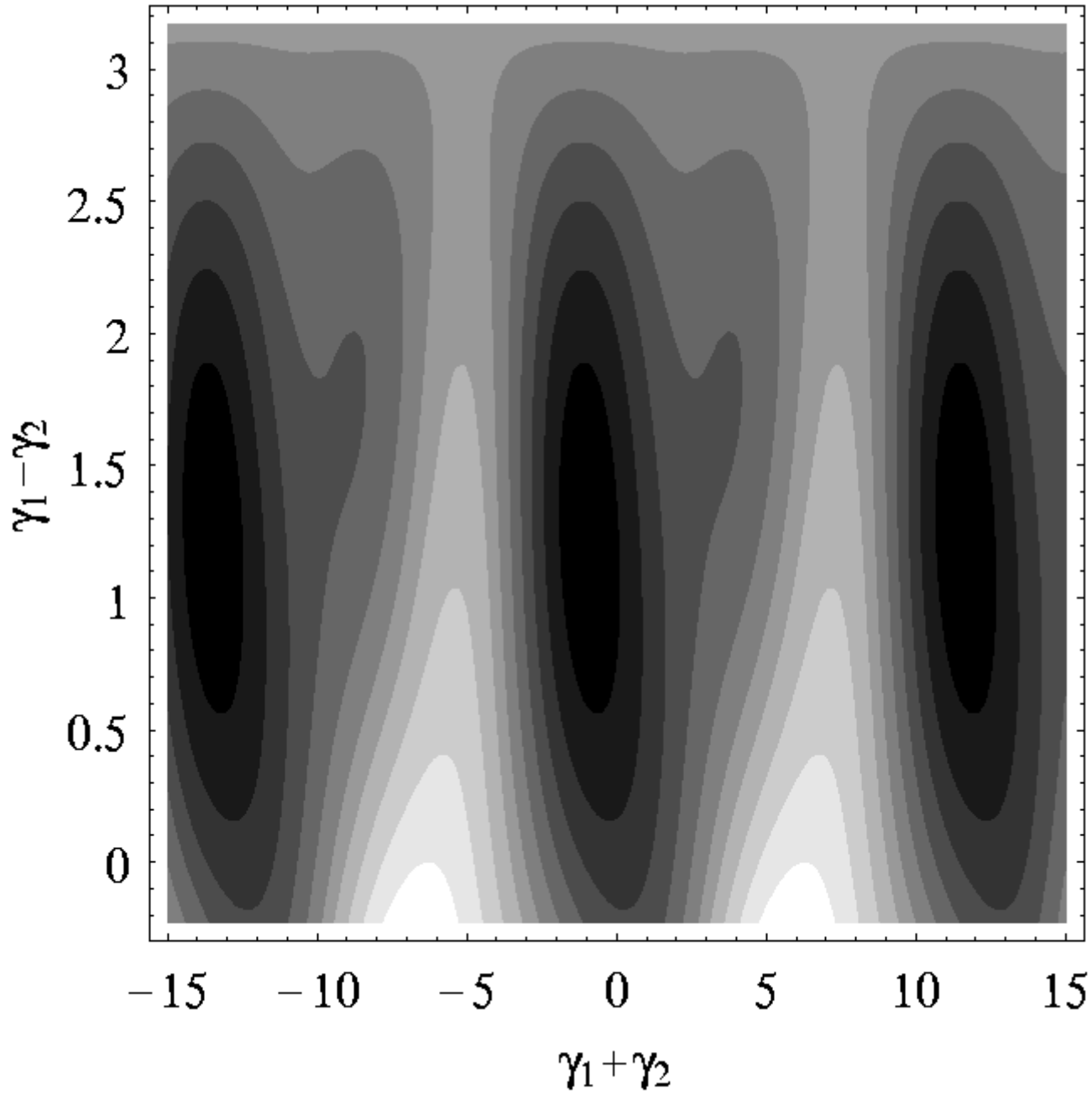
$$I_{J1,2} = I_{C1,2}(\sin\gamma_{1,2} \pm \beta \sin 2\gamma_{1,2})$$

Taking into account conservation of charge and the relation between magnetic flux and quantum phase

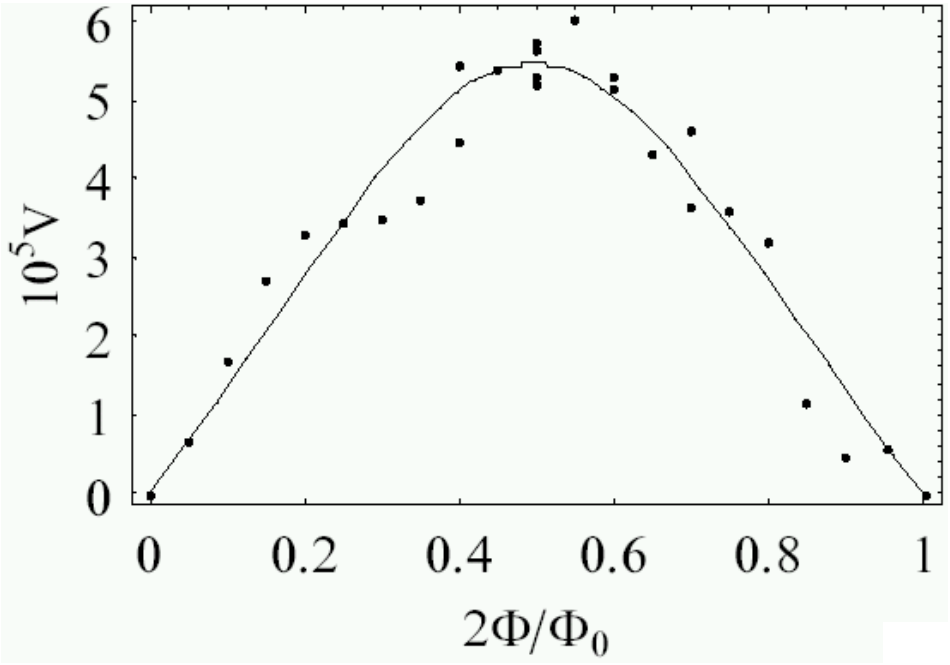
$$C_i \ddot{\gamma}_i + \dot{\gamma}_i / R_i + \text{noise} =$$

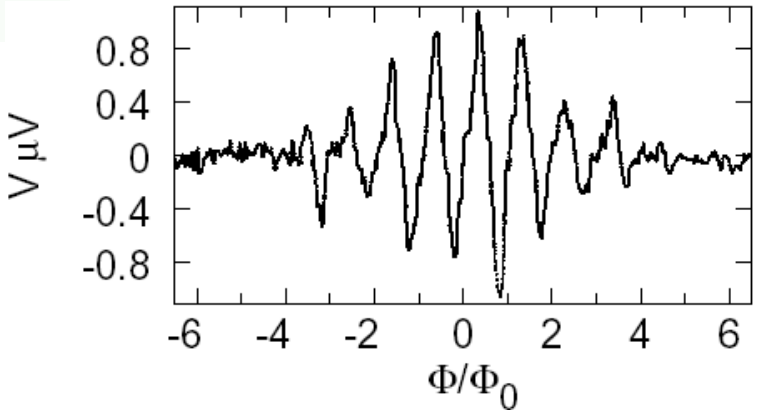
$$-I_{Ci}(\sin\gamma_i + (-1)^i \sin 2\gamma_i) - (-1)^i(\varphi_x + \gamma_2 - \gamma_1)/L$$

$$= -\partial U(\gamma_1, \gamma_2)/\partial\gamma_i$$


3
2.5
2
1.5
1
0.5
0
$\gamma_1-\gamma_2$
−15
−10
−5
0
5
10
15
$\gamma_1+\gamma_2$

Quantitative result



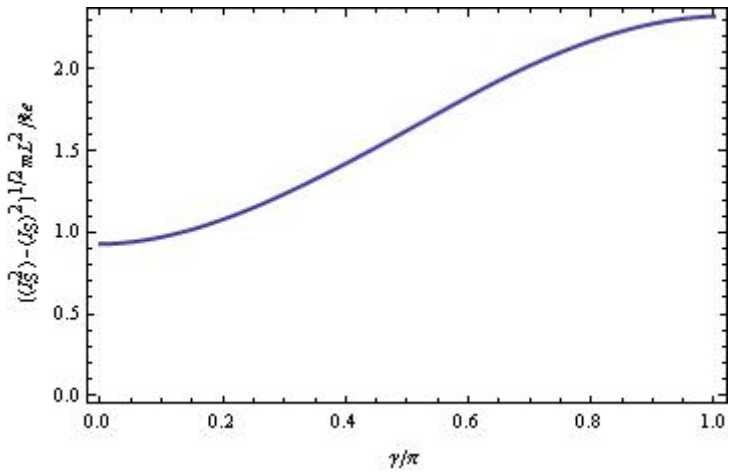


Supercurrent fluctuation

$$\text{Josephson current} = I_c\left(\sin\gamma + \beta_2 \sin 2\gamma + \cdots\right)$$

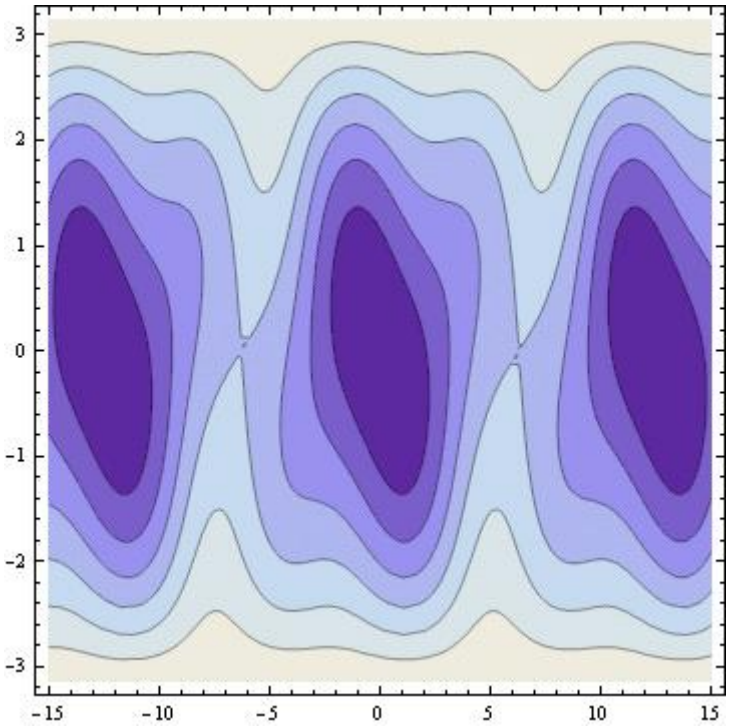
size $\propto |\psi|^2$
Fluctuates

shape

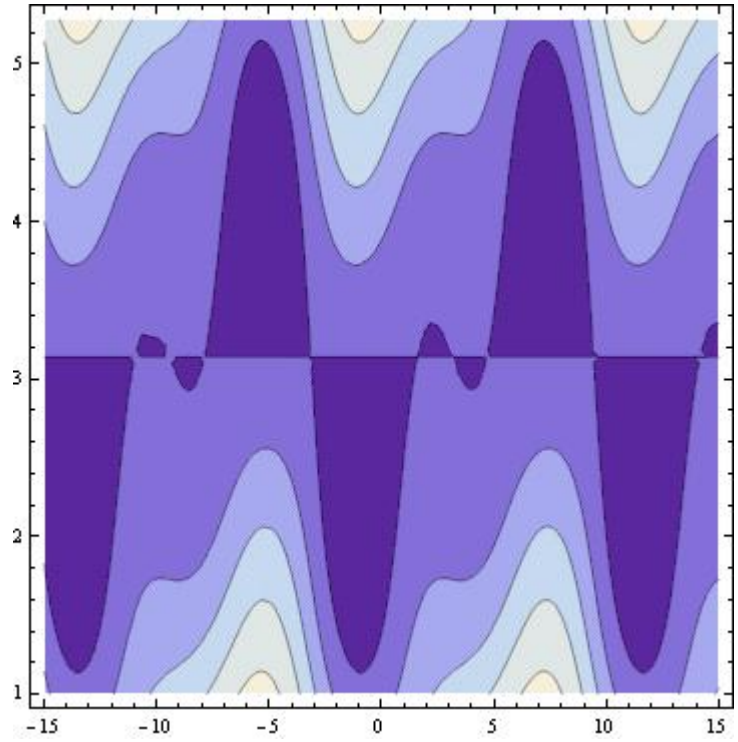


In lieu of conclusion:

I hope this problem served as food for thought and met your taste. Thank you for bearing with me.



$\Phi = 0$



$\Phi = 0.5\Phi_0$