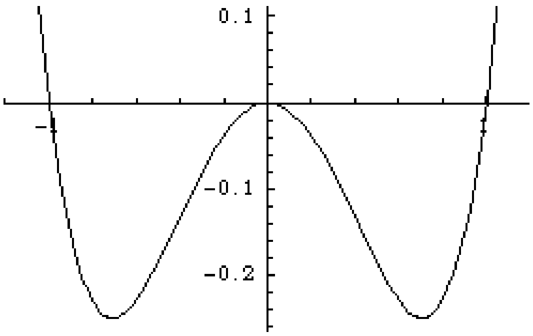
The potential looks like (in this graph a=b=1):



The periods get large because there is the hump in the middle, coming from the $-bx^2$ term, which dominates for sufficiently small x. Particles with nearly zero energy will have very small velocity here, and so spend a lot of time (since there is only small acceleration as well). This is why the periods become large.

We can write down energy conservation for each period, assuming damping is small:

$$E = \frac{1}{2}mv^2 - ax^2 + bx^4$$

solving for the velocity:

$$v^2 = \frac{2}{m}\left(E + ax^2 - bx^4\right)$$

So we can find the period by:

$$t = \int_{-\delta x}^{\delta x} \frac{\sqrt{m/2}}{\sqrt{E + ax^2 - bx^4}}$$

If we take δx of the integration to be $\ll \sqrt{a/b}$, we can neglect the x^4 term, and get:

$$t = \int_{-\delta x}^{\delta x} \frac{\sqrt{m/2}}{\sqrt{E + ax^2}}$$

which we recognize as the arcsinh:

$$t = \sqrt{m/2a}\,\mathrm{arcsinh}\left(\frac{\delta x\sqrt{a}}{\sqrt{E}}\right)$$

Considering δx fixed, when we reduce E we can rewrite the arcsinh:

$$\sinh x = y = \frac{e^x - e^{-x}}{2} \Rightarrow \ln(2y) = \ln\left(e^x - e^{-x}\right)$$

For large y, to get positive x, x must be large, which means:

$$\ln(2y) \approx \ln\left(e^x - 1\right) \approx x \Rightarrow \mathrm{arcsinh}\, y \approx \ln(2y)$$

Plugging in:

$$t = \sqrt{m/2a}\ln\left(\frac{2\delta x\sqrt{a}}{\sqrt{E}}\right)$$

Only considering the dependence on E:

$$t \sim -\ln(E) + const$$

Now we consider the damping to be linear with rate \kappa :

$$E_i = E_0 - \kappa i$$

where E_0 is the initial energy. We can write the critical value of i as $i_0 = E_0 / \kappa$, so that $E_i = \kappa(i_0 - i)$, which gives the time dependence:

$$t \sim -\ln(i_0 - i) + const$$

The period will increase to infinity as it approaches the critical period, and then flatten out as it enters harmonic oscillation: