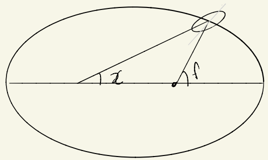


$$\ddot{x} = -\varepsilon\left(\frac{a}{r(t)}\right)^3 \sin\left(2x - 2f(t)\right)$$

$$\dot{x} = y$$

$$\dot{y} = -\varepsilon\left(\frac{a}{r(t)}\right)^3 \sin\left(2x - 2f(t)\right)$$

Kepler

$$r(t) = a(1 - e\cos u)$$

$$f(t) = 2\arctan\left(\sqrt{\frac{1+e}{1-e}}\tan\frac{u}{2}\right)$$

$$l_0 = u - e\sin u$$

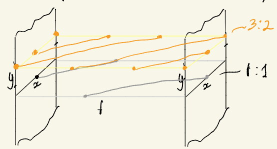
$$\dot{x} = y$$
$$\dot{y} = F(x,t)$$
$$\dot{t} = 1$$

$x \in S^1$, $\dot{x} \in \mathbb{R}$

$f \in S$

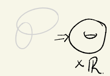
Sección de Poincaré

(Mapeo de primer retorno)

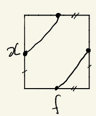


$S^1 \times S^1 \times \mathbb{R}$

$\mathbb{T}^2 \times \mathbb{R}$

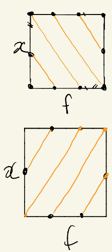


Luna



Resonancia 1:1

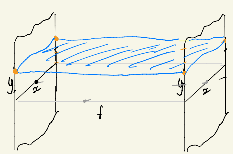
Mercurio



Resonancia 3:2

2 vueltas a f

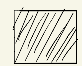
3 vueltas a x



~ Esta superficie es un toro $\mathbb{T}^2$.

~ Este es un toro invariante del espacio fase.

Kepler 3141



¿Qué pasaría si $\frac{x}{f} \in \mathbb{R}\setminus\mathbb{Q}$?

Tendríamos una trayectoria que llena densamente el toro.

- Órbita Cuasi-periódica

$$r(t) = a(1 - e\cos u)$$

$$f(t) = 2\arctan\left(\sqrt{\frac{1+e}{1-e}}\tan\frac{u}{2}\right)$$

$$l_0 = u - e\sin u$$

Si $e = 0$ (círculo), en este caso

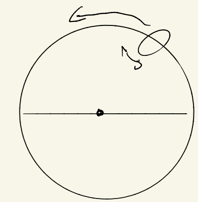
$r = a$

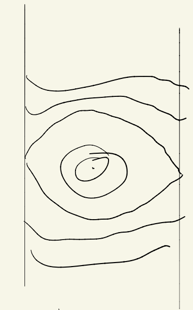
$f = t - t_0$

$\ddot{x} + \varepsilon\sin(2x - 2t - 2t_0) = 0$

$\theta = 2x - 2t - 2t_0$

$\ddot{\theta} + \varepsilon\sin(\theta) = 0$ ¡Esto es el péndulo!





En el caso integrable