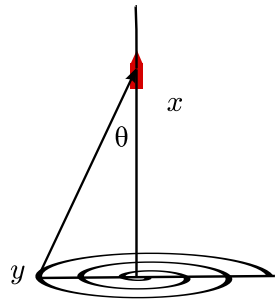
1. Intergalactic Travel: Enjoying the View
   Suppose at some point in the future we build a rocket that allows us to leave the Milky Way. What wonderful sights will we see as we look out the front window of our rocket as we leave the Milk Way behind? It turns out that if we go fast enough we will see a distorted image of the Milk Way! In this question we will explore this phenomenon.



   (a) Consider the picture above showing a rocket moving at speed v at a distance x from the galaxy below with a ray coming from the edge of the galaxy and meeting the rocket at an angle θ. These measurements are made in the galaxy frame. Find expressions for V_x and V_y, the x and y components of the velocity of the pulse of light reaching the the rocket in the direction shown.

   (b) Use the relativistic velocity addition to find V'_x and V'_y, and given the constancy of the speed of light determine two different relationships between the angle of incidence of the light in the spaceship frame θ' and the angle in the galaxy frame θ .

   (c) When $\theta' > 90$ the galaxy will appear to be in front of the spaceship. How fast would you need to be traveling for an angle $\theta = 30^o$ to appear as an angle of $\theta' = 150$

   (d) In order for any object that is behind you (ie with $\theta < 90$ to appear in front of you (ie with $\theta' => 90$) you need to be traveling at a minimum speed Find that minimum speed in terms of c and θ. Find an expression for the minimum boost factor γ. If we make it to Andromeda, how fast do we need to be traveling to see the Milk Way ahead of us?

   (e) Why can't the the center of the galaxy be seen ahead?

   (f) If the galaxy where a series of circular rings what would it look like when seen from the front window of a high speed spaceship. Where would the image of an inner ring of the galaxy appear relative to an outer ring of the galaxy?

   (g) How would the appearance of the galaxy change as the spaceship moved further from the galaxy, assuming constant speed?

   (h) Imagine that you started in the plane of the galaxy and fired your rocket with a constant acceleration. What is the minimum acceleration required so that the galaxy is always visible ahead of you? Express your answer in terms of the radius of the galaxy R and the speed of light c. (Hint: Recall the parametric equation for the world line with constant acceleration).