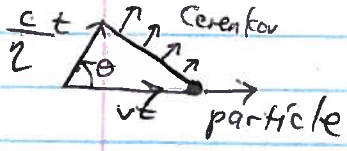
Mach cone

In this case, the particle travels faster than its own wavefronts. The wavefronts will expand in a cone behind the particle, called a <u>shock wave</u>. The physics here is similar to a particle exceeding the sound speed.

This shock wave carries energy, & thus is a form of radiation.



$$\cos\theta = \frac{ct/n}{vt} = \frac{1}{n\beta}$$

The emitted radiation has (where $v > c/n$) $I_\nu \propto \nu$, so in optical is <u>blue</u>. Cutoff in UV spectrum, as $v < c/n$, in e.g. water.

Cerenkov light

So the angle of incidence tells <u>velocity</u> of particle.

Applied in several situations:

- nuclear reactors, to measure fission frequency
- particle physics
- studying high-energy cosmic rays & gamma-rays, by measuring Cerenkov radiation from particles produced by the γ-rays (or CRs) air shower.

VERITAS schematic

HESS image

HESS movie

Telescope arrays with high effective area, fast (ns) response time; resolution limited by air shower spread.

Multiple telescopes provide multiple views of shower allowing reconstruction.

HESS has identified 64 TeV γ-ray sources, mostly SNRs, & pulsar wind nebulae, & blazars.

- Neutrino detectors identify Cerenkov radiation from high-E neutrinos creating electrons or muons.

IceCube detects Cerenkov radiation with photomultipliers under ice, looking for muons going <u>up</u>, which <u>aren't</u> cosmic rays.

IceCube

Ice Cube from air