Modeling CrIS Nonlinearity
**** DRAFT ****

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We consider the definition of reference truth for measurements made with a Michelson interferometer, taking into account relatively small (or possibly non-existant) effects such as filter position and potential mathematical artifacts. The immediate application is defining reference truth and a corresponding calibration equation for the for the CrIS instrument.

1 Michelson Interferometer

Figure 1 shows a basic Michelson interferometer. Let $r_{\text{in}}(\nu)$ be incoming radiance as a function of frequency ν, δ mirror displacement, and $r_{\text{out}}(\nu, \delta)$ radiance on the path to the detector. In practice the signal from the detector is the product of incoming radiance, beam-splitter efficiency, and detector responsivity. But suppose for the moment that we have a perfect beam splitter and mirrors, and that there are no filters. Then radiance r_{out} on the path to the detector can be represented as

$$r_{\text{out}}(\nu, \delta) = r_{\text{in}}(\nu)(1 + \cos 2\pi\nu\delta)/2 \tag{1}$$

including a term $r_{\text{in}}(\nu)/2$ that depends only on ν. Integrating over frequency, we have

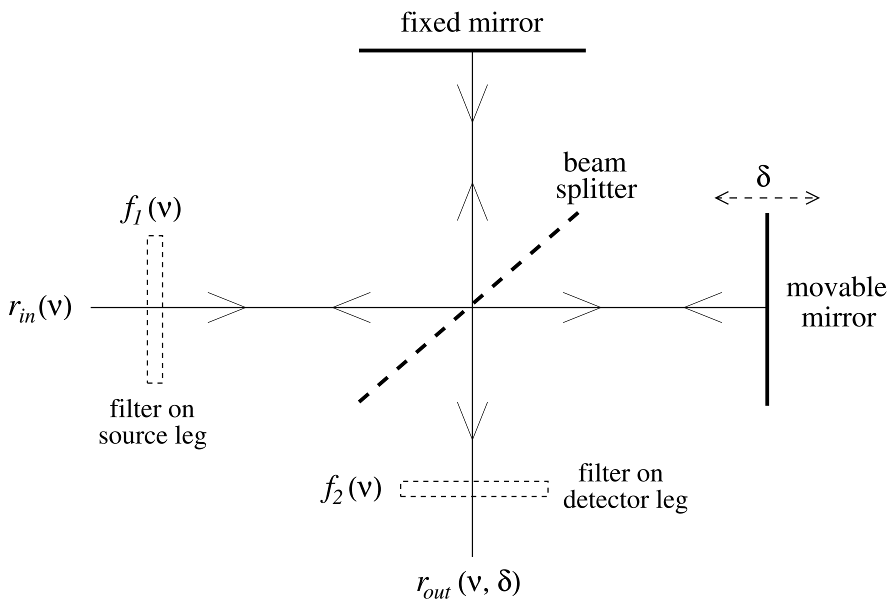

Figure 1: Michelson interferometer with filters

$$r_{\text{out}}(\delta) = \frac{1}{2}\int_{\nu=0}^{\text{inf}} r_{\text{in}}(\nu)d\nu + \frac{1}{2}\int_{\nu=0}^{\text{inf}} r_{\text{in}}(\nu)\cos(2\pi\nu\delta)d\nu \tag{2}$$

This is the continuous interferogram as a function of displacement δ. We want the consider the AC' and DC components separately.

$$r_{\text{DC}}(\delta) = \frac{1}{2}\int_{\nu=0}^{\text{inf}} r_{\text{in}}(\nu)d\nu, \quad r_{\text{AC}}(\delta) = \frac{1}{2}\int_{\nu=0}^{\text{inf}} r_{\text{in}}(\nu)\cos(2\pi\nu\delta)d\nu \tag{3}$$

r_{DC} is a function of the scene, while r_{AC} is a function of both the scene and mirror position. For $\delta = 0$ (zero mirror displacement) the two terms are identical.

Figure 2 shows sample transfer functions, taking radiance to voltage. $G_1(r)$ and $G_2(r)$ are linear, of the form $G(r) = br + c$, for some b and c. For CrIS c is Vinst, a DC bias value, while b depends on analog gain and detector properties. $G_3(r)$ is a plausible arbitrary nonlinear transfer function.

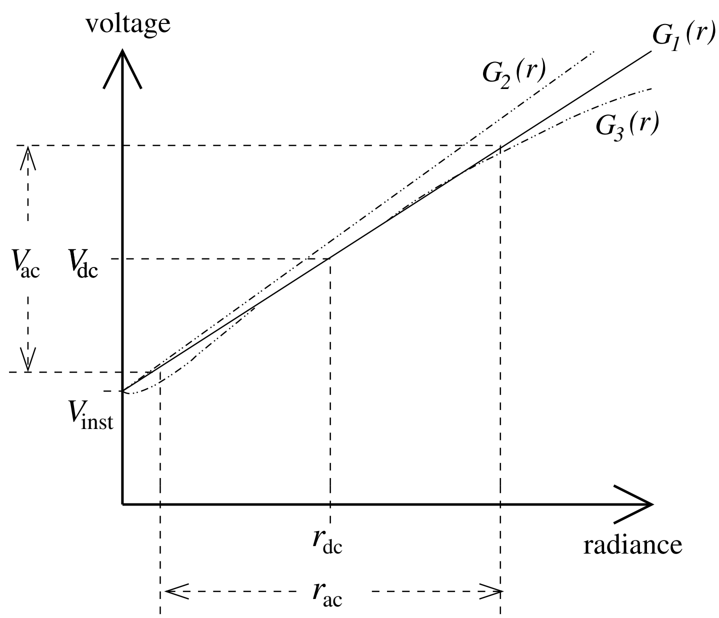

Figure 2: Gain Function