I. INTRODUCTION

Magnetic polaritons are electromagnetic waves that travel in a material with dispersion and properties modified through coupling to magnetic excitations[1]. Polaritons can display a number of interesting and useful properties, including localization to surfaces and edges, and non-reciprocity[1–4], whereby propagation frequency may not symmetric under direction reversal: i.e. $\omega(k) \neq \omega(-k)$. Surface polaritons at optical frequencies have received much attention in recent years, and appear in a number of different applications including detectors[5], biosensors[6] and microscopy[7].

Theoretical treatments for ferromagnetic polaritons[2,8] and simple antiferromagnets[1,9,10] were made several years ago. A most interesting class of polaritons are in multiferroic materials where magnetoelectric interactions couple magnetic and electric responses[4,11,12]. A focus of theoretical work has been on bulk modes in linear magnetoelectric coupled media[4,11]. Surface modes have also been discussed for the case of no applied external magnetic or electric fields, and neglecting canting of magnetic sublattices[12,13].

Modification and control of multiferroic surface polaritons through external electric and magnetic fields is an intriguing prospect. In the present paper we discuss in detail how temperature, electric and magnetic fields affect surface modes in canted spin multiferroics with linear magnetoelectric coupling. We allow for canting of magnetic sublattices, and show that canting is very important for understanding and manipulating surface mode frequencies. Most significantly, we show that the transverse magnetic field polarisation (TM) surface polariton excitations are in fact pseudo-surface modes characterized by complex propagation wavevectors whose imaginary parts are proportional to the strength of the magnetoelectric interaction.

Linear magnetoelectric coupling is believed to operate in multiferroics $BaMnF_4$[14] and $FeTiO_3$[15]. In order to make contact with previous work on bulk polaritons, we concentrate here on the $BaMnF_4$ system. The paper is organized as follows. The geometry and energy density of the system are considered in Section II where we also discuss the canting angle in relation to the magnetoelectric coupling. In section III, susceptibilities are derived using Bloch and Landau-Khalatnikov equations. The electromagnetic problem is solved in Section IV and results given in Section V for surface and bulk modes on $BaMn_4$. In Section VI, effects on surface mode properties due to possible modifications of material parameters are