Accepted 31/05/2021
Typeset using LATEX **twocolumn** style in AASTeX63

Probing jets from young embedded sources: clues from *HST* near-IR [Fe II] images

Jessica Erkal,[1] Brunella Nisini,[2] Deirdre Coffey,[1] Francesca Bacciotti,[3] Patrick Hartigan,[4]
Simone Antoniucci,[2] Teresa Giannini,[2] Jochen Eislöffel,[5] and Carlo Felice Manara[6]

[1] *School of Physics, University College Dublin, Belfield, Dublin 4, Ireland*
[2] *INAF, Osservatorio Astronomico di Roma, via Frascati 33, 00078, Monte Porzio Catone, Italy*
[3] *INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125, Firenze, Italy*
[4] *Physics and Astronomy Dept., Rice University, 6100 S. Main, Houston, TX 77005-1892*
[5] *Thüringer Landessternwarte, Sternwarte 5, 07778, Tautenburg, Germany*
[6] *European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748, Garching bei München, Germany*

(Received 20/03/2021; Accepted 31/05/2021)

Submitted to ApJ

ABSTRACT

We present near-infrared [Fe II] images of four Class 0/I jets (HH 1/2, HH 34, HH 111, HH 46/47) observed with the Hubble Space Telescope Wide Field Camera 3. The unprecedented angular resolution allows us to measure proper motions, jet widths and trajectories, and extinction along the jets. In all cases, we detect the counter-jet which was barely visible or invisible at shorter wavelengths. We measure tangential velocities of a few hundred km/s, consistent with previous HST measurements over 10 years ago. We measure the jet width as close as a few tens of au from the star, revealing high collimations of about 2 degrees for HH 1, HH 34, HH 111 and about 8 degrees for HH 46, all of which are preserved up to large distances. For HH 34, we find evidence of a larger initial opening angle of about 7 degrees. Measurement of knot positions reveals deviations in trajectory of both the jet and counter-jet of all sources. Analysis of asymmetries in the inner knot positions for HH 111 suggests the presence of a low mass stellar companion at separation 20-30 au. Finally, we find extinction values of 15-20 mag near the source which gradually decreases moving downstream along the jet. These observations have allowed us to study the counter-jet at unprecedented high angular resolution, and will be a valuable reference for planning future JWST mid-infrared observations which will peer even closer into the jet engine.

Keywords: ISM: jets and outflows - protostars

1. INTRODUCTION

Bipolar jets are a key ingredient in the star formation process, but the role they play is not yet fully understood (Frank et al. 2014). They are found to transport significant amounts of mass and momentum away from the newly forming star, but theoretical models still struggle to agree on their basic formation mechanism (e.g. Ferreira et al. 2006).

Most research to-date has focused on more evolved (Class II) sources which have already cleared their surrounding envelopes and therefore are easier to observe with optical instrumentation (Frank et al. 2014). However, to understand the earlier evolutionary stages, we must also study jets from less evolved (Class 0/I) sources. These sources are still highly embedded in their dusty envelope and dense cloud of material and the resulting large extinction prevents an accurate determination of their physical properties close to the star. Consequently, detailed studies of extended jets from these objects are usually performed only far from the central source (i.e. $\gtrsim 10$"), where the problem of extinction becomes less severe. In these regions, however, the jet has already interacted with the ambient medium through multiple shocks, loosing the pristine information about its acceleration mechanism.

Corresponding author: Jessica Erkal
jessica.erkal@ucdconnect.ie