

In the format provided by the authors and unedited.

A 10,000-solar-mass black hole in the nucleus of a bulgeless dwarf galaxy

Jong-Hak Woo ^{1*}, Hojin Cho ¹, Elena Gallo², Edmund Hodges-Kluck^{2,3,4}, Huynh Anh N. Le^{1,5},
Jaejin Shin ¹, Donghoon Son¹ and John C. Horst⁶

¹Department of Physics and Astronomy, Seoul National University, Seoul, Republic of Korea. ²Department of Astronomy, University of Michigan, Ann Arbor, MI, USA. ³Department of Astronomy, University of Maryland, College Park, MD, USA. ⁴NASA/GSFC, Greenbelt, MD, USA. ⁵Department of Astronomy, University of Science and Technology, Hefei, China. ⁶San Diego State University, San Diego, CA, USA. *e-mail: woo@astro.snu.ac.kr

80 minute light echo signalling a 10,000 solar mass black hole in a bulgeless dwarf galaxy

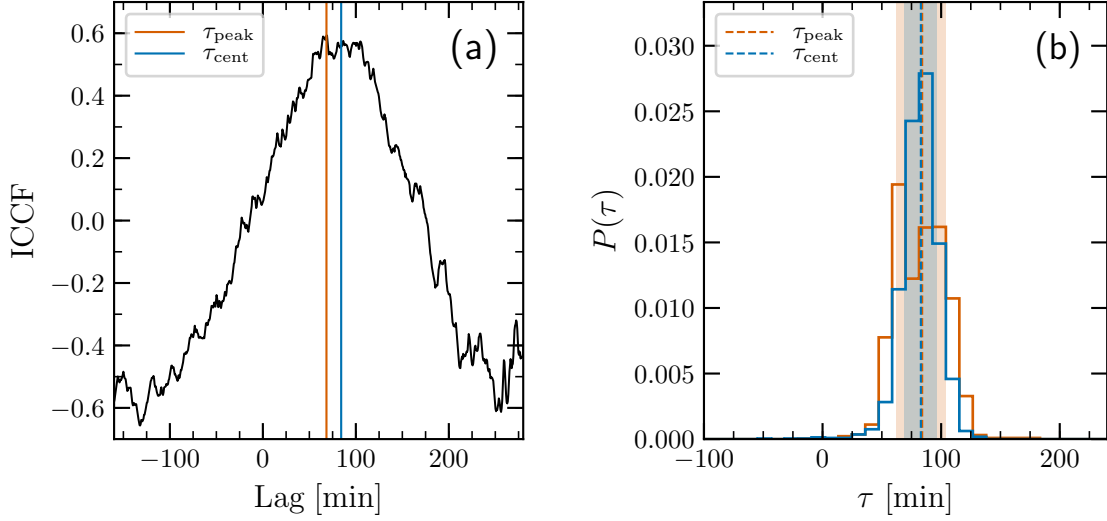


Figure 1: **H α lag measurements based on cross-correlation analysis.** (a) The peak and centroid lags for the cross-correlation coefficient are denoted with red and blue lines, respectively. We define the centroid time lag (τ_{cent}) as the ICCF-weighted average lag for values larger than 80% of the maximum ICCF. (b) We present the normalized distributions of τ_{cent} (blue) and τ_{peak} (red) as measured from 2000 realizations of the continuum-corrected V and H α light curves. We adopt the median and central 68% interval width $\tau_{\text{cent}} = 83 \pm 14$ min from the distribution (blue dashed line and blue shaded region). The median and central 68% interval width of τ_{peak} is also presented (red dashed line and red shaded region).

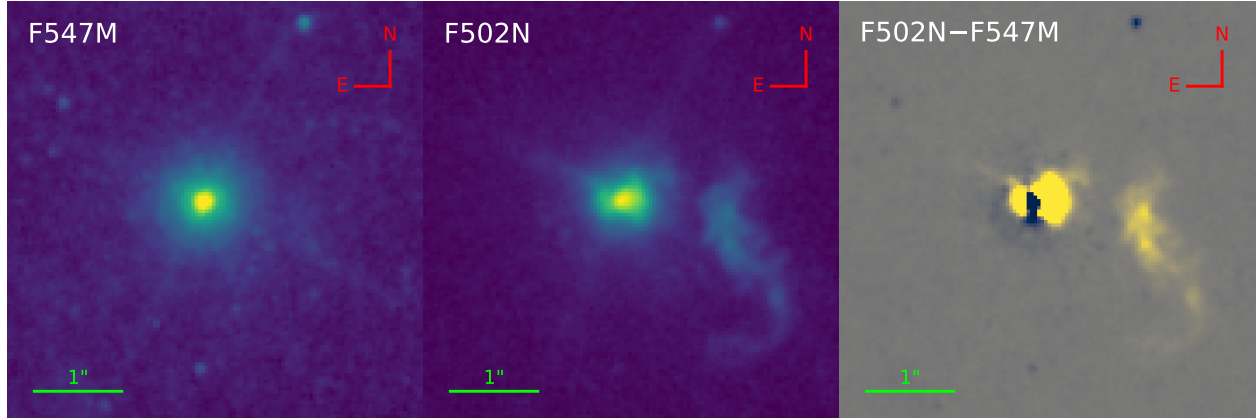


Figure 2: **Biconical [OIII] outflow.** The *HST* F547M continuum filter (left) shows the stellar continuum from the nuclear star cluster and the continuum emission from the AGN. The F502N filter image (center) shows the [OIII] emission from ionized gas, but includes some continuum emission. After subtracting the scaled continuum from the F502N image, only the [OIII] remains (right). The continuum-subtracted image reveals a biconical, but asymmetric, outflow, which indicates that the axis of the [OIII] outflow is inclined relative to our line of sight.