GROUND-BASED OBSERVATIONS OF 2022 WJ1 AND 2023 CX1 ASTEROID ENTRIES. D. Vida[1], A. Egal[1,2], P. G. Brown[1], J. Borovička[3], P. Spurný[3], P. Wiegert[1], H. A. R. Devillepoix[4], F. Colas[5], D. Šegon[6], P. McCausland[1], M. McIntyre[7], [1]Dept of Physics and Astronomy, The University of Western Ontario, London, ON, Canada (dvida@uwo.ca), [2]Planetarium Rio Tinto Alcan, Montreal, QC, Canada, [3]Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic, [4]Space Science & Technology Centre, School of Earth and Planetary Sciences, Curtin University, Bentley, WA, Australia, [5]IMCCE, Observatoire de Paris, Paris, France, [6]Astronomical Society "Istra", Pula, Croatia, [7]UK Meteor Network

Introduction:

In November 2022 and February 2023, two small asteroids 2022 WJ1 and 2023 CX1 were discovered prior to entering the Earth's atmosphere, giving observers on the ground enough warning to observe the associated fireball. Both dropped meteorites on the ground. In contrast to the previous five asteroids discovered before impact, these occurred over densely populated areas and were observed by dedicated fireball cameras, which enabled rapid trajectory and strewn field estimation. Most meteorites dropped by 2022 WJ1 fell in Lake Ontario, but meteorites dropped by 2023 CX1 in Normandy (France) were quickly recovered. For the first time, the complete set of data are available for a small solar system body: telescopic characterization (orbit, colors, rotation), atmospheric observations (trajectory, light curve, fragmentation behavior), and meteorite analysis (radionuclide analysis, cosmochemistry, petrology).

Our work reports for the first time on optical observations of the two events using photographic and video methods, the comparison between the telescopic orbit and the orbit reconstructed from fireball observations, preliminary fragmentation modelling, and meteorite analysis. We highlight developments in trajectory and photometry reconstruction and the critical new role of informed amateur observers. For future events, we suggest preparing data collection guidelines for the general public to increase the quality of targeted observations and we propose a warning system to increase the number of observers.

2022 WJ1:

See the talk by Wiegert et al. for more details about the circumstances of the fall, the meteorite search, and non-optical observations. The fireball associated with 2022 WJ1 was observed over southwestern Ontario on November 19, 2022, at 08:26:40 UTC by an array of instruments operated by the Western Meteor Physics Group (WMPG), the Global Fireball Observatory (GFO), as well as the Global Meteor Network (GMN). Observation was difficult due to overcast weather and due to the late hour (3 AM) and short warning time only a handful of observers witnessed the event. We reconstruct the atmospheric trajectory exclusively using instrumental records, achieving a fit within ±100 m over the length of ~200 km. Photometry was difficult as all cameras saturated. A saturation curve of a WMPG all-sky video camera was calibrated using a light source of known brightness. A peak absolute magnitude of about -14 was derived, just at the limit of GOES-GLM satellite sensitivity which did not see it.

2023 CX1:

2023 CX1 was discovered about 7 hours prior to impact while people in France were still not asleep giving enough warning time for targeted observations. We reconstruct the trajectory using three GMN cameras in the UK, one FRIPON camera in France, and several other targeted observations which were crucial in observing the end of the fireball. A complete unsaturated light curve was observed using a low-cost prototype lux meter with absolute calibration, but only through clouds. A peak magnitude between -17 and -18 was measured (~1 m pre-atmospheric diameter).

Orbit comparison:

The table below compares the telescopic orbits from JPL (J) and Neodys (N) to the preliminary orbits derived from fireball observations (F). We integrate asteroid orbits and the fireball state vectors 60 days prior to impact to avoid any planetary perturbations. The fireball orbits match the telescopic orbits within the estimated uncertainties, giving confidence to the fireball analysis methodology. Both objects were most likely injected into near-Earth space through the ν_6 resonance.

	a (AU)	e	i (°)	Ω (°)	ω (°)
			2022 WJ1		
J	1.8727	0.50433	2.5821	56.7456	35.036
±	*0.0003*	*9.5e-05*	*0.0005*	*0.0001*	*0.003*
N	1.87359	0.50457	2.58312	56.7455	35.0388
±	*6.7e-05*	*1.9e-05*	*7.7e-05*	*5e-06*	*0.0001*
F	1.8758	0.50783	2.517	56.7328	35.346
±	*0.1154*	*0.01095*	*0.239*	*0.0129*	*0.9055*
			2023 CX1		
J	1.62929	0.43456	3.4183	323.870 9	218.788
±	*8.9e-5*	*4.4e-5*	*0.0008*	*7.2e-5*	*0.0052*
N	1.62917	0.43451	3.4177	323.870	218.787
±	*1.9e-5*	*7.2e-6*	*5.7e-5*	*3e-6*	*7.8e-5*
F	1.6255	0.4323	3.4152	323.844	218.90
±	*0.0596*	*0.0287*	*0.3456*	*0.0416*	*2.35*