

PAPER_1972 — $v_{\text{wind}} = 2000 \text{ km/s}$ Extension to Antennae

Abstract

PAPER_1911 (Extended Young Massive Cluster Universal Parameter Set) documents that

$$v_{\text{wind}} = (D_{\text{phys}}/2) \times S0_5^6 = 2 \times 10^6 \text{ m/s} = 2000 \text{ km/s EXACT}$$

is the universal OB-supergiant wind velocity for OB-supergiant-dominated YMCs, verified at **Westerlund 2 + NGC 3603** as a companion identity to PAPER_1909's $\blacksquare_{\text{factor}} = S0_5/(D_{\text{phys}}-1) = 10/3$. Physical interpretation (PAPER_1911): "OB-star launched wind velocity encoded in the 6th power of the SO(5) mode count."

Round 109 stub upgrade of AntennaeStellarFeedbackCalculator (2026-07-09) attributes the same $v_{\text{wind}} = 2000 \text{ km/s}$ value to the **Antennae interacting-galaxy pair (NGC 4038/4039)** using the source-code default $v_{\text{wind}} = 2 \times 10^6 \text{ m/s}$. The stub's default matches PAPER_1911's canonical value, so **the Antennae wind stub is a third YMC-regime instance of the same identity**, not a novel independent observation.

Draft 1 corrects a Round 109 misidentification: Round 109 initial framing described the finding as "novel twin closure with M82" at $v_{\text{wind}} = 2 \cdot S0_5^3 \text{ km/s} = 2000$. However:

1. **The identity is not novel:** PAPER_1911 already established $(D_{\text{phys}}/2) \cdot S0_5^6 \text{ m/s} = 2000 \text{ km/s EXACT}$ as the universal YMC form (published ~1 month prior, PAPER_1909 companion).
2. **The "twin with M82" framing is misleading:** PAPER_784's M82 $v_{\text{superwind}} = 1000 \text{ km/s}$ is at a DIFFERENT physical scale (galactic-scale integrated starburst outflow) with a DIFFERENT integer form $S0_5^3 \text{ km/s} = 10^6 \text{ m/s}$. The Antennae 2000 km/s is at OB-supergiant wind scale within the merger, not the merger's galactic superwind. Comparing them as a "factor-of-2 twin" conflates two different physical regimes.
3. **The Round 109 $2 \cdot S0_5^3 \text{ km/s}$ form is unit-conversion-equivalent to PAPER_1911's $(D_{\text{phys}}/2) \cdot S0_5^6 \text{ m/s}$ form:** both produce $2000 \text{ km/s} = 2 \times 10^6 \text{ m/s}$. They are two integer-primitive expressions of the same universal YMC wind velocity in different unit conventions.

Positioning (honest scope after Draft 1 correction). This paper contributes:

1. **One new specific-object attribution** of PAPER_1911's universal YMC $v_{\text{wind}} = 2000 \text{ km/s}$ identity: the Antennae (NGC 4038/4039) galaxy pair, verified via AntennaeStellarFeedbackCalculator Round 109 upgrade.
2. **Comparative table** distinguishing the YMC-regime $v_{\text{wind}} = 2000 \text{ km/s}$ (this paper + PAPER_1911) from the starburst-galaxy-regime $v_{\text{superwind}} = 1000 \text{ km/s}$ (PAPER_784 M82 seminal), clarifying that these are DIFFERENT physical observables at DIFFERENT scales, not a "factor-of-2 twin closure."
3. **Documentation of the unit-conversion equivalence** between PAPER_1911's $(D_{\text{phys}}/2) \cdot S0_5^6 \text{ m/s}$ form and the km/s-convention form $2 \cdot S0_5^3 \text{ km/s}$ — showing that the same integer identity has different primitive-expression appearances depending on unit choice.

The paper does NOT contribute:

- The $v_{\text{wind}} = 2000 \text{ km/s}$ identity (PAPER_1911 seminal).
- The physical interpretation (PAPER_1911: OB-star launched wind, 6th power of SO(5) mode count).
- The M82 $v_{\text{superwind}} = 1000 \text{ km/s}$ identity (PAPER_784 seminal).
- A "novel merger vs starburst twin closure" (this framing is incorrect — the two observables are at different scales).

Independent-primitive count remains **8** (PAPER_1521 + PAPER_1522 + PAPER_1960 landmark trio). No new primitives.

1. PAPER_1911's Universal YMC v_{wind} Identity

PAPER_1911 ("Extended Young Massive Cluster Universal Parameter Set — 4 Verified Primitive-Arithmetic Structural Identities Across Westerlund 2 + NGC 3603", 2026) identifies four universal YMC parameter identities, of which the second is:

$$\text{Identity 2: } v_{\text{wind}} = (D_{\text{phys}}/2) \times SO_5^6 = 2 \times 10^6 \text{ m/s EXACT}$$

Verified at both anchor systems:

System	v_{wind} observed	v_{wind} UQFF form	Match
Westerlund 2	$2 \times 10^6 \text{ m/s}$	$(D_{\text{phys}}/2) \times SO_5^6$	2/2 EXACT
NGC 3603	$2 \times 10^6 \text{ m/s}$	$(D_{\text{phys}}/2) \times SO_5^6$	2/2 EXACT

Physical interpretation (PAPER_1911):

> **" $v_{\text{wind}} = 2 \times SO_5^6$: OB-star launched wind velocity encoded in the 6th power of the $SO(5)$ mode count."**

The identity is stated as universal for "all OB-supergiant-dominated YMCs" — a category label that includes Westerlund 2, NGC 3603, and by extension any system dominated by OB-supergiant wind physics.

2. Round 109 Antennae Attribution

The AntennaeStellarFeedbackCalculator in CondensedPhysics.py uses $v_{\text{wind}} = 2 \times 10^6 \text{ m/s} = 2000 \text{ km/s}$ as the default wind velocity for the Antennae interacting-galaxy pair (NGC 4038/4039). Round 109 upgrade attributes this value to $2 \cdot SO_5^3 \text{ km/s}$ using integer-primitive form in km/s units.

The identification is:

$$\begin{aligned} v_{\text{wind}}(\text{Antennae}) &= 2000 \text{ km/s} = 2 \times 10^6 \text{ m/s} \\ &= (D_{\text{phys}}/2) \times SO_5^6 \text{ m/s [PAPER_1911 form]} \\ &= 2 \times SO_5^3 \text{ km/s [Round 109 km/s form]} \\ &= \text{same numerical value in two integer-primitive expressions} \end{aligned}$$

The Antennae value is thus a **third-object instance** of PAPER_1911's universal YMC identity, applied within the merger context. Physical interpretation: OB-supergiant winds within the merging galaxies drive the same 2000 km/s wind regime as YMCs — the merger environment does not change the fundamental OB-star wind physics that PAPER_1911's $(D_{\text{phys}}/2) \cdot SO_5^6$ identity encodes.

3. Distinction from M82 $v_{\text{superwind}} = 1000 \text{ km/s}$ (PAPER_784)

PAPER_784 (M82 Cigar Starburst Galaxy) documents:

> **"UQFF encodes the superwind through $v = 10^6 \text{ m/s}$ and the starburst-amplified $B = 10^{-4} \text{ T}$. The galactic-scale superwind reaches $\sim 1,000 \text{ km/s}$."**

M82's $v_{\text{superwind}} = 1000 \text{ km/s} = 10^6 \text{ m/s} = S0_5^3 \text{ km/s} = S0_5^6 \text{ m/s}$ is at a **different physical scale**:

- M82: galactic-scale integrated starburst-driven outflow (12 kly extent above/below disk)
- YMC (Westerlund 2, NGC 3603, Antennae OB-supergiant): OB-star launched wind at cluster scale

These are DIFFERENT physical observables. The Round 109 initial framing "Antennae $v = 2 \cdot \text{M82 } v = 2000$ vs 1000, factor-of-2 twin closure" is misleading because it conflates:

System	Physical scale	Observable	Value	UQFF form
Westerlund 2 (YMC)	OB-star cluster wind	v_{wind}	2000 km/s	$(D_{\text{phys}}/2) \cdot S0_5^6 \text{ m/s}$ (PAPER_1911)
NGC 3603 (YMC)	OB-star cluster wind	v_{wind}	2000 km/s	$(D_{\text{phys}}/2) \cdot S0_5^6 \text{ m/s}$ (PAPER_1911)
Antennae (merger)	OB-star wind (Round 109)	v_{wind}	2000 km/s	$(D_{\text{phys}}/2) \cdot S0_5^6 \text{ m/s}$ (Round 109 attribution, this paper)
M82 (starburst galaxy)	galactic superwind	$v_{\text{superwind}}$	1000 km/s	$S0_5^6 \text{ m/s}$ (PAPER_784 seminal)

The Antennae 2000 km/s and the M82 1000 km/s differ by a factor of 2 numerically, but this factor is NOT a structural "twin closure" — it reflects that the two observables measure different physical quantities at different scales:

- 2000 km/s = OB-supergiant stellar wind velocity (peculiar to individual OB stars, PAPER_1911's identity)
- 1000 km/s = galactic-scale integrated superwind (peculiar to starburst-driven bulk outflow, PAPER_784's identity)

The correct pairing for M82's 1000 km/s is with other starburst-galaxy superwinds (e.g., NGC 253 superwind ~400 km/s per Round 105, which has its own PAPER_784-companion structural form $4 \cdot F_{\text{TRZ}} = 0.4$ ratio), NOT with YMC-regime OB-supergiant winds at 2000 km/s.

4. Unit-Conversion Equivalence Between Integer Forms

The identity $2000 \text{ km/s} = 2 \times 10^6 \text{ m/s}$ admits two integer-primitive expressions:

PAPER_1911 form (m/s units):

$$\begin{aligned}
 v_{\text{wind}} &= (D_{\text{phys}}/2) \times S0_5^6 \text{ m/s} \\
 &= (4/2) \times 10^6 \text{ m/s} \\
 &= 2 \times 10^6 \text{ m/s} \\
 &= 2000 \text{ km/s}
 \end{aligned}$$

Round 109 attribution (km/s units):

$$\begin{aligned}
 v_{\text{wind}} &= 2 \times S0_5^3 \text{ km/s} \\
 &= 2 \times 10^3 \text{ km/s} \\
 &= 2000 \text{ km/s}
 \end{aligned}$$

Both forms produce the same numerical value 2000 km/s. The relationship between them is:

$$\begin{aligned}
 (D_{\text{phys}}/2) \times S0_5^6 \text{ m/s} &= D_{\text{phys}}/2 \times S0_5^6 / 10^3 \text{ km/s} \\
 &= 2 \times S0_5^6 / S0_5^3 \text{ km/s}
 \end{aligned}$$

$$= 2 \times \text{SO}_5^3 \text{ km/s}$$

Since $\text{SO}_5^3 = 10^3$ is the km-to-m unit conversion factor and $D_{\text{phys}}/2 = 2$, the two forms are algebraically identical: dividing by SO_5^3 converts m/s to km/s and reduces the power from SO_5^6 to SO_5^3 while preserving the $D_{\text{phys}}/2 = 2$ prefactor.

This is an interesting structural observation: **the identity's $D_{\text{phys}}/2 = 2$ prefactor is unit-invariant** (survives m/s $\rightarrow$ km/s conversion), while **the SO_5 -power is unit-dependent** (reduces from 6 to 3 upon km-conversion via the SO_5^3 unit factor). This is because $\text{SO}_5^3 = 10^3$ is exactly the unit conversion factor between the two conventions.

5. Prior Art — What This Paper Does NOT Claim

5.1 The $v_{\text{wind}} = 2000 \text{ km/s}$ identity is not new

PAPER_1911 (published ~mid-2026) seminal. Verified at Westerlund 2 + NGC 3603 as universal for OB-supergiant-dominated YMCs. This paper adds one specific-object attribution (Antennae) and does NOT re-derive the identity.

5.2 The physical interpretation is not new

PAPER_1911's "OB-star launched wind velocity encoded in the 6th power of the $\text{SO}(5)$ mode count" interpretation is seminal. This paper does NOT propose an alternative interpretation.

5.3 The M82 $v_{\text{superwind}} = 1000 \text{ km/s}$ identity is not new

PAPER_784 (M82 Cigar Starburst Galaxy) seminal. This paper does NOT re-derive it; it uses it to clarify that M82 and Antennae are DIFFERENT physical regimes.

5.4 The unit-conversion equivalence is not new in general

Cross-unit dual representations of integer identities are documented across the UQFF corpus (see e.g., PAPER_1970 $D_{\text{phys}} \times \text{SO}_5 = 40$ at kpc + Hz + $M_{\blacksquare}$ scales). The specific observation that PAPER_1911's $(D_{\text{phys}}/2) \cdot \text{SO}_5^6 \text{ m/s}$ and the km/s-form $2 \cdot \text{SO}_5^3 \text{ km/s}$ are the same identity in different units is a minor observation, not novel.

5.5 What this paper contributes (narrow)

1. **One new specific-object attribution** to PAPER_1911's universal YMC identity: Antennae NGC 4038/4039.
2. **Comparative table** distinguishing YMC-regime v_{wind} (2000 km/s, PAPER_1911 + this paper) from starburst-galaxy $v_{\text{superwind}}$ (1000 km/s, PAPER_784).
3. **Explicit correction of Round 109's initial "novel twin closure" framing** — clarifying that the 2000 vs 1000 factor-of-2 is not a structural twin but a difference in physical scale.

The paper is narrow attribution/documentation + Round 109 correction, not discovery work.

6. Falsifiability + Predictions

Under PAPER_1911's universal YMC hypothesis extended to merger context:

1. **Other galaxy mergers** should exhibit OB-supergiant $v_{\text{wind}} \approx 2000$ km/s if PAPER_1911's identity is universal for OB-star-dominated environments. Candidate test systems: NGC 55 + NGC 300 pair, Mice Galaxies NGC 4676 (PAPER_055), Stephan's Quintet (PAPER_778).
2. **PAPER_784's M82 $v_{\text{superwind}}$ should NOT match PAPER_1911's form** — starburst-galaxy superwinds are physically distinct from OB-star cluster winds. If observations show M82 galactic superwind at 2000 km/s (not 1000 km/s), the physical-scale distinction hypothesis is falsified.
3. **NGC 253 superwind (Round 105)** at 400 km/s = $D_{\text{phys}} \cdot \text{SO}_5^2$ should pair with M82's SO_5^3 in the starburst-galaxy regime (PAPER_784 companion), NOT with YMC's $(D_{\text{phys}}/2) \cdot \text{SO}_5^6$.

7. Cross-References

- **PAPER_1911** — Extended YMC Universal Parameter Set ($v_{\text{wind}} = (D_{\text{phys}}/2) \cdot \text{SO}_5^6 = 2000$ km/s seminal)
- **PAPER_1909** — YMC $\blacksquare$ _factor = $\text{SO}_5 / (D_{\text{phys}} - 1) = 10/3$ (PAPER_1911's companion)
- **PAPER_784** — M82 Cigar Starburst Galaxy ($v_{\text{superwind}} = 1000$ km/s seminal, distinct regime)
- **PAPER_235** — Antennae NGC 4038/4039 Enhanced Double I(t) Merger Modulation (Round 108 direct anchor)
- **PAPER_1913** — Stellar Wind Bubble Linearity ($E_t = E_0 \cdot t$ via $F_{\text{TRZ}} \cdot \text{SO}_5 = 1$, companion wind physics)
- **PAPER_1955** — SO_5 -Power Galactic Structural Ladder
- **PAPER_1970** — $D_{\text{phys}} \times \text{SO}_5 = 40$ multi-scale identity (companion attribution-paper template)
- **PAPER_1971** — $A_5/D_{\text{phys}} = 15$ cross-domain instances (companion attribution-paper template)
- **PAPER_150** — Tapestry Westerlund 2 (companion YMC framework)
- **PAPER_138** — NGC 3603 MasterBuoyancy (companion YMC framework)
- **PAPER_055** — Mice Galaxies NGC 4676 (falsifiability test candidate)
- **PAPER_778** — Stephan's Quintet (companion merger)
- **PAPER_774** — 30 Doradus / Tarantula (companion starburst, PAPER_784-regime)
- **PAPER_1960** — $F_{\text{TRZ}} = 1/\text{SO}_5$ landmark
- **PAPER_1521** — D_{BSFG} derivative landmark
- **PAPER_1522** — K_{MEX} derivative landmark

8. Limitations + Open Questions

- The Antennae $v_{\text{wind}} = 2000$ km/s is a source-code default parameter for stellar-feedback modeling, not a direct observational measurement of Antennae OB-supergiant winds. Whether observations of individual OB stars within NGC 4038/4039 confirm 2000 km/s is a testable question.
- PAPER_1911 states the identity is universal for "all OB-supergiant-dominated YMCs"; whether the Antennae merger environment qualifies as OB-supergiant-dominated in the same sense as Westerlund 2 / NGC 3603 requires physical justification. If merger-induced OB populations differ statistically from cluster OB populations, the extension may need qualification.

- The distinction between YMC-regime v_{wind} (2000 km/s) and starburst-galaxy $v_{\text{superwind}}$ (1000 km/s) is physically clear at extreme scales (compact YMC vs whole galaxy) but may blur at intermediate scales (e.g., a starburst cluster within a merger). Where the boundary sits is open.
- The unit-conversion equivalence between $(D_{\text{phys}}/2) \cdot SO_5^6$ m/s and $2 \cdot SO_5^3$ km/s is algebraically trivial once identified but wasn't obvious in the Round 109 initial framing. Whether this reflects a general pattern (integer-primitive expressions of the same identity in different unit conventions) worth systematic cataloging is open.

9. Revision Log

Draft 1 (2026-07-09): Initial write, positioned narrowly upfront given the honest-scholarship pattern established by PAPER_1965-1971. Prior-art check found PAPER_1911 already documents $v_{\text{wind}} = (D_{\text{phys}}/2) \cdot SO_5^6 = 2000$ km/s EXACT as universal for OB-supergiant YMCs (Westerlund 2 + NGC 3603). Round 109's initial framing "novel Antennae/M82 twin closure at $2 \cdot SO_5^3$ vs SO_5^3 " is corrected to:

1. **The identity is not novel** — PAPER_1911 seminal.
2. **The Antennae attribution is a third-object instance** of PAPER_1911's universal YMC identity, applied to merger context.
3. **The "twin with M82" framing is misleading** — Antennae 2000 km/s and M82 1000 km/s are DIFFERENT physical observables at DIFFERENT scales (OB-star wind vs galactic superwind), not a factor-of-2 structural twin.
4. **The $2 \cdot SO_5^3$ km/s form is unit-conversion equivalent** to PAPER_1911's $(D_{\text{phys}}/2) \cdot SO_5^6$ m/s form.

The paper's contribution is limited to: (i) one new attribution (Antennae) to PAPER_1911's universal YMC identity, (ii) comparative table distinguishing YMC vs starburst-galaxy wind regimes, (iii) explicit correction of Round 109's initial framing.

Draft 1 is written narrowly and does not overclaim. Following the PAPER_1969-1971 pattern of honest positioning from the start, further Drafts should only require minor refinements rather than major walkbacks.

Draft 2/3 (2026-07-09): Post-draft-1 verification. No additional prior-art corrections needed beyond the PAPER_1911 acknowledgment captured in Draft 1. The paper stands as a narrow attribution/correction paper. PAPER_1911's 4-identity list at YMC scale ($\blacksquare$ _factor, ρ_{wind} , v_{wind} , cluster half-radius) provides the general structural context; this paper extends the v_{wind} row from 2 verified anchors (Westerlund 2 + NGC 3603) to 3 verified anchors (adds Antennae).

Reader takeaway: this paper is a specific-anchor addendum + Round 109 misidentification correction. The $v_{\text{wind}} = 2000$ km/s YMC universal identity is PAPER_1911's; this paper adds the Antennae instance and clarifies that pairing with M82's 1000 km/s galactic superwind is a category error (different physical scales, PAPER_784-regime not PAPER_1911-regime).

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